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ORIGINAL ARTICLES.

I.—Some New British Carboniferous Cockroaches.

By Henry Woodward, LL.D., F.R.S., F.G.S.

(PLATE II.)

THE early appearance in geological time of terrestrial Arthropods has always been to me a subject of deep interest, and I have been fortunate in noticing several of these in the pages of this Magazine and elsewhere.[1]

The oldest insect at present recorded is the impression of an Orthopterous wing referred to the family Blattidæ, obtained from the Silurian sandstone of Jurques, Calvados, France, about the horizon of the May Hill Sandstone (Middle Silurian). M. Charles Brongniart, its discoverer, observes that what is especially remarkable about this fossil, and which distinguishes it from all other Cockroach-wings, living or fossil, is the length of the anal vein, and the narrowness of the axillary area.

This primitive insect has been named by him *Palæoblattina Douvillei*.[2]

The occurrence of Cockroaches in the Coal-measures of Germany (Wettin) was announced by Germar as early as in 1842.[3]

The only example heretofore met with in England was obtained by Mr. James W. Kirkby (and described by him in the Geol. Mag. 1867, Vol. IV. Pl. XVII. Figs. 6–8, pp. 388–390), from the Coal-measures, opposite Claxheugh, near Sunderland; but little attention seems to have been given to its discovery.[4]

By far the most important Memoir on Palæozoic Cockroaches which has yet appeared is that by Mr. Samuel H. Scudder, of

[1] See on *Eophrynus* (*Curculioides*) *Prestvici*, Buckl. sp., Geol. Mag. 1871, Vol. VIII. Pl. XI. pp. 385–388.

On *Architarbus subovalis*, H. Woodw. *op. cit.* 1872, Vol. IX. Pl. IX. p. 385.

On *Brachypyge carbonis*, H. Woodw. *op. cit.* 1878, Dec. II. Vol. V. Pl. XI. p. 434. [I described this form as a Crustacean; but it has since been suggested to me by Mr. S. H. Scudder that it was more probably the abdomen of an Arachnide nearly related to *Eophrynus*.—H. W.]

On *Lithomantis carbonarius*, H. Woodw. Quart. Journ. Geol. Soc. Lond. 1876, vol. xxxii. pl. ix. pp. 60–64.

On *Eoscorpus carbonarius*, H. Woodw., *op. cit.* 1876, pl. viii. pp. 57–59.

On "Spined Myriapods," Geol. Mag. 1887, No. I. p. 1. Pl. I.

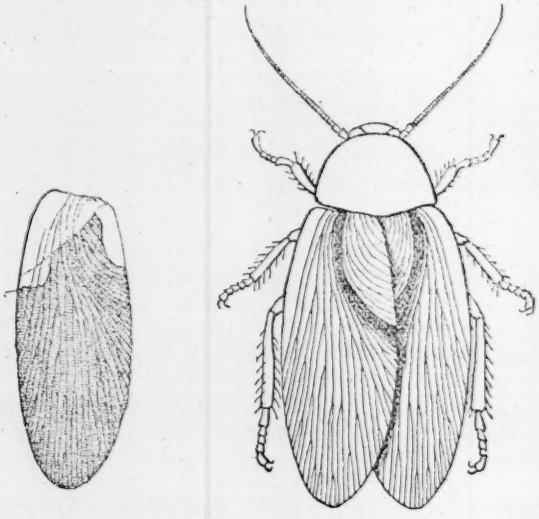
[2] "Comptes Rendus," Acad. des Sciences, Paris, No. 29, Decr. 26, 1884.

[3] See Münster's Beiträge zur Petrefactenkunde, Stuttgart.

[4] Mr. S. H. Scudder has since named it *Etoblattina mantidioides*, Mem. Boston Soc. Nat. Hist. 1879, vol. iii. pt. i. No. 3, pp. 72–73 (woodcut).

Boston, who has not only described all the species that have come to his hands from the Coal-measures of N. America, but many European ones also, and has given us "a complete revision of the species of both worlds" (see Mem. Boston Soc. Nat. Hist. Boston, 1879, 4to. vol. iii. pp. 23–134, and plates 2–6).

According to a still later summary on "The Cockroach of the Past" (published as an appendix to "The Structure and Life-History of the Cockroach (*Periplaneta orientalis*)," by Prof. L. C. Miall and Alfred Denny, London, 1886, 8vo.), Mr. Scudder gives the number of Carboniferous *Palæoblattariæ* at 70 species.



1. 2.

Figs. 1 and 2.—*Progonoblattina* (*Blatta*) *helvetica*, Heer (Swiss Cockroach), from the Coal-measures of Erbignon.

1. Wing, of the natural size. 2. The animal restored.

Reproduced from Prof. O. Heer's Primæval World of Switzerland, London, 1876 (translated by W. S. Dallas, F.L.S.), 2 vols. 8vo. p. 20, fig. 16*c*.

It must, however, be borne in mind that our knowledge of this ancient type of Orthopterous Insect is derived almost entirely from its wings; and upon the well-marked variations which the principal veins present in their arrangement (see Fig. 3).

Scudder, who adopts the terminology proposed by Prof. Oswald Heer, of Zurich, writes:—"These principal veins are six, counting the marginal vein, which here merely thickens the anterior border, as one; and starting from the anterior margin, they are the *marginal, mediastinal, scapular, externo-median, interno-median*, and *anal*. The general disposition of these veins is as follows:—The 'mediastinal' and 'scapular' veins, with their branches, which are superior (*i.e.* part from the main vein on the upper or anterior side), terminate

upon the anterior margin. The 'interno-median' and 'anal' take the opposite course, and their branches are inferior, or, at least, directed towards the inner margin; while the 'externo-median,' which is interposed between these two sets, terminates at the tip of the wing, and branches indifferently on either side."

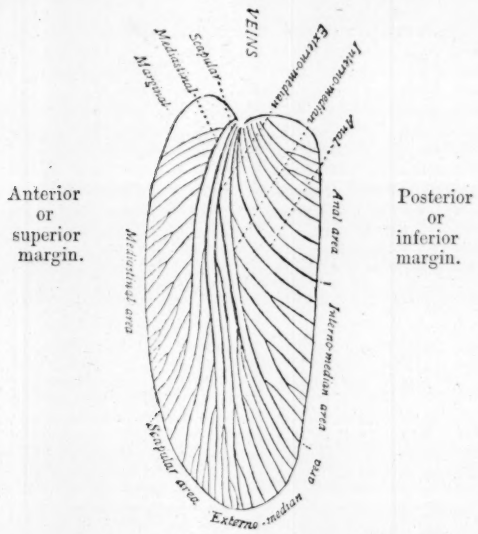


FIG. 3.—Schematic view of left wing of Palæozoic Cockroach, showing the veins and areas (after Scudder).

"Now these veins are all present in both front and hind wings of Palæozoic Cockroaches, and also in the hind wings of existing species; but in the front wings or *tegmina* of the latter, the number is never complete, the externo-median vein being always amalgamated either with the scapular, or with the interno-median, and the mediastinal frequently blended with the scapular vein" (Scudder).

The following is a list of the genera and species of BLATTIDÆ from the Carboniferous formation hitherto described, arranged under the families and genera suggested by Scudder.

PALÆOBLATTARIÆ.

Mylacridæ—

Mylacris bretonense, Scudder,	Coal-measures,	Sydney,	Cape Breton.
,, *Heerii*, Scudder,	,,	,,	,,
,, *pennsylvanicum*, Scudder	,,	Cannelton,	Penn. U.S.
,, *Mansfieldi*, Scudder	,,	,,	,,
,, *anthracophilum*, Scudder	,,	Colchester,	Illinois, U.S.
,, *antiquum*, Scudder	,,	Port Griffith,	Pittston.
,, *lucifugum*, Scudder	,,	,,	,,
,, *carbonum*, Scudder	,,	Cannelton,	Penn. U.S.
,, *ovale*, Scudder	,,	,,	,,
,, *priscovolans*, Scudder	,,	,,	,,

Promylacris ovale, Scudder, Coal-measures, Mazon Creek, Illinois, U.S.
,, *rotundum*, Scudder ,, ,, ,,
Paromylacris rotundum, Scudder ,, ,, ,,
Lithomylacris pauperatum, Scud. ,, Pittston, Penn. U.S.
,, *pittstonianum*, Scudder ,, ,, ,,
,, *angustum*, Scudder ,, ,, ,,
,, *simplex*, Scudder ,, Danville, Illinois.
Necymylacris heros, Scudder ,, Cannelton, Penn. U.S.
,, *lacoanum*, Scudder ,, Pittston, Luzerne Co. Penn.

BLATTINARIÆ.

Etoblattina mantidioides, Gold. ,, Durham, England.
,, *didyma*, Rost ,, Manebach.
,, *manebachensis*, Gold. ,, ,,
,, *primæva*, Scudder ,, Auerswald, Saarbruck.
,, *labachensis*, Scudder ,, Lebach ,,
,, *insignis*, Gold. ,, ,,
,, *euglyptica*, Germ. ,, Wettin, Saxony.
,, *affinis*, Gold. ,, Lobejün.
,, *flabellata*, Germ. ,, Wettin, Saxony.
,, *anthracophila*, Germ. ,, ,, ,,
,, *Dohrnii*, Scudder ,, ,, ,,
,, *anaglyptica*, Germ. ,, ,, ,,
,, *carbonaria*, Germ. ,, ,, ,,
,, *russoma*, Gold., ,, Lobejün.
,, *leptophlebica*, Gold. ,, ,,
,, *parvula*, Gold. ,, ,,
,, *spectabilis*, Gold. ,, ,,
,, *lanceolata*, Sterzel ,, Lugau.
,, *venusta*, Lesq. ,, Arkansas.
,, *Mazona*, Scudder ,, Mazon Creek, Illinois.
,, *Lesquereuxii*, Scudder ,, Appalachian.
Archimylacris parallelum, Scudder ,, Pennsylvania.
,, *acadicum*, Scudder ,, Picton, Nova Scotia.
,, *paucinerve*
Anthracoblattina winteriana, Gold. ,, Saarbrück.
,, *Remigii*, Dohrn. ,, Cusel, Rhenish Bavaria.
,, *spectabilis*, Gold. ,, Wettin, Saxony.
,, *dresdensis*, Gein. ,, Klein-Opitz, near Dresden.
Gerablattina Goldenbergii, Mahr. ,, Manebach.
,, *clathrata*, Heer ,, ,,
,, *Mahri*, Gold. ,, ,,
,, *weissiana*, Gold. ,, Brücken, Rhenish Bavaria.
,, *intermedia*, Gold. ,, Wemmetsweiler.
,, *Geinitzii*, Gold. ,, Lobejün.
,, *Münsteri*, Gold. ,, Wettin, Saxony.
,, *producta*, Gold. ,, ,, ,,
,, *Germari*, Gutb. ,, ,, ,,
,, *scaberata*, Gold. ,, Attenwald.
,, *latinervis* ,, Saxe-Weimar, Ilmenau.
,, *fascigera*, Scudder ,, Pittston, Pennsylvania.
,, *balteata*, Scudder ,, W. Virginia and Ohio.
Hermatoblattina wemmetsweileriensis, Gold. Coal-measures, Saarbrück.
,, *Tischbeini*, Gold. ,, ,,
Progonoblattina Fritschii, Heer ,, Manebach.
,, *Helvetica*, Heer ,, Valais, Swiss.
Oryctoblattina reticulata, Germar ,, Wettin.
,, *occidua*, Scudder ,, Mazon Creek, Illinois.
Petrablattina sepulta, Scudder ,, Sydney, Cape Breton.
,, *bretonense*, Scudder ,, ,, ,,
Anthracoblattina Scudderi, Gold. ,, Saarbrück.

Three of the specimens about to be described (namely, Pl. II. Figs. 1, 2, 3), are in nodules from the Clay-ironstone band, between

the "Brooch" and the "Thick-coal" at Coseley, near Dudley, and form a part of the valuable collection made by the late Mr. Henry Johnson, F.G.S., Mining Engineer, of Dudley, now preserved in the British Museum of Natural History, Cromwell Road, London.

The remaining specimen (Plate II. Fig. 4*a*, *b*) was placed in my hands some years since, by the kindness of Mr. James W. Kirkby, who obtained it from the Upper Coal-measures, near Meithil, on the Fifeshire coast.

Fig. 4.—*Etoblattina Mazona*, Scudder (1½ times nat. size), Carboniferous, Illinois (after Scudder).

Etoblattina Johnsoni, sp. nov. (Pl. II. Figs. 1*a*, 1*b*.)

With the exception of *Blattina insignis* of Goldenberg from the Coal of Saarbrück, and *Etoblattina Mazona*, Scudder, from the Carboniferous of Illinois (Woodcut Fig. 4), this is one of the most perfect Cockroaches yet discovered in the Coal. The specimen is exposed in a small oval clay-ironstone nodule, so fortunately split open, as to show an equally well-preserved impression and counterpart of the fossil. The pronotum or prothorax is rounded in front, being 13 millimetres broad and 8 mm. long, and is divided into two parts by a straight line, clearly visible both on the impression and counterpart; the central part of the shield has a slightly raised pyriform area, pointed in front and broadly truncated behind; the surface is transversely wrinkled and bears a pair of minute spots near the anterior point. The hinder border of the shield is rounded and somewhat deeply emarginated on the median line.

The mesothorax is 8 mm. broad, but its length cannot be seen, being covered by the wings.

The paired wings measure 25 mm. in breadth and 28 mm. in length (they were probably about 3 mm. longer, but their edges are

lost on the border of the nodule). The metathorax and abdomen are not visible, being covered by the closely-folded wings.

It has been a matter of no small difficulty to the artist accurately to trace out the venation of the wings in this specimen. When a single wing is preserved on the surface of a piece of shale, its veins can usually be traced distinctly; but when two pairs of superposed wings have to be studied, they present, after compression, a somewhat complex problem to unravel. I believe, however, that the outline (Pl. II. Fig. 1*b*, and 1*a*, nat. size) gives a fairly accurate representation of the veins. The wing is oblong-ovate in form; the 'mediastinal' vein commences at the proximal end of the wing, about 3 mm. within the border, and runs almost parallel with the superior marginal vein, but gradually bends towards, and unites with it, at 20 mm. from its commencement. It gives off, at first, several single branches, followed by five equidistant bifurcating ones; the 'scapular' vein takes its origin at the proximal end, close to the 'mediastinal' vein, and after pursuing a course nearly parallel to it, it terminates on the anterior distal margin of the wing, 25 mm. from its commencement, giving off five simple branch-veins from its superior border. The 'externo-median' vein takes its rise from the inferior side of the 'scapular' vein, about half-way in its course, and extending to the extremity of the wing, it gives off one single superior and one bifurcated inferior branch.

The 'interno-median' follows the course of the conjoined 'externo-median' and 'scapular' veins, arching towards the inferior or interno-median margin of the wing, giving origin in its course to six inferior branch-veins about equidistant from each other, the first (proximally) being bifid, the second simple, the third, fourth and fifth bifurcated, and the sixth simple. The anal area of the wing is strongly marked by the arched anal vein which is branched, and is followed by about five simple similarly arched veinlets, whose origin appears to be along the inner proximal border of the wing.

The whole surface of the wings exhibits a very delicate tracery produced by the slighly-elevated microscopic net-work of cross-veins, which need the aid of a magnifying glass to reveal, and are not attempted to be represented in our Plate.[1]

Several of the species of *Etoblattina*, figured by Scudder, present a general resemblance in form and in the distribution of the veins to our specimen; but they differ materially in the area which the branches of each principal vein occupies. There is not one in which the 'scapular' and 'externo-median' veins rise half-way down the wing from a common main trunk. This is a character which has been frequently observed in the veins of the front wings, or *tegmina*, of existing species (Scudder). It would require, however, a far larger series of specimens than we possess, and at least several examples of each species (a consummation devoutly to be wished for, but not the least likely to be fulfilled), before one could venture to speak with any degree of confidence of species founded on such fragmentary evidence as we at present possess.

[1] Mr. Scudder's artist has successfully reproduced this wonderful and complex lace-structure in *Etoblattina venusta*, Lesquereux (Scudder, *op. cit.* pl. 6, fig. 12, p. 70).

I have much pleasure in dedicating this species to the memory of its discoverer, the late Mr. Henry Johnson, F.G.S., Mining Engineer of Dudley, than whom I have never known a more earnest and enthusiastic worker, a more assiduous collector, or one who more willingly lent his specimens for scientific purposes to those who requested their loan.

The specimen was obtained from an ironstone nodule from Coseley near Dudley, and is now preserved as a part of the "Johnson Collection" in the British Museum (Natural History).

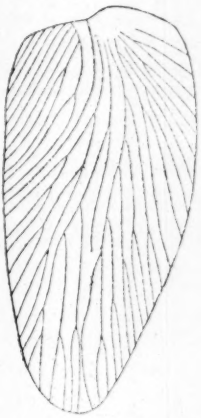


Fig. 5.—Right wing of *Mylacris anthracophilum*, Scudder, × 2 nat. size, Carboniferous, Illinois (after Scudder).

Lithomylacris Kirkbyi, sp. nov. Plate II. Fig. 4*a*, *b*.

This specimen consists of a single detached left wing preserved on the surface of a piece of thin purple shale from "Bed No. 33" in the Upper Coal-measures near Meithil, on the coast of Fifeshire. This shale-bed, which overlies the lower coal and thin limestone, contains, with rootlets, rare specimens of species of *Neuropteris*, *Pecopteris*, and *Cyclopteris*, along with an *Anthracomya*.[1]

Although the border of the wing is somewhat imperfect, sufficient is preserved to show its general form, and the venation of the wing stands out in distinct relief on its surface.

Outline of wing pointed-ovate, slightly flattened on its superior border; length of wing 15 mm., breadth 8 mm. The 'mediastinal' vein occupies rather more than a fourth of the entire area of the wing; it extends to about two-thirds of the length, where it unites with the superior margin of the wing; it branches six times, one of these branches has three forks. The 'scapular' vein extends nearly to the extremity of the wing; it remains single for over one-fourth of its length, and then branches into three veins, the middle one of

[1]For a full account of this area see a paper "On the Upper Beds of the Fifeshire Coal-measures," by Edward W. Binney, F.R.S., and James W. Kirkby, Esq. (Quart. Journ. Geol. Soc. Lond. 1882, vol. xxxviii. pp. 245-256, pl. vi.)

which is again forked. The 'externo-median' vein continues parallel to the scapular vein, for a slightly longer distance before it branches at the extremity of the wing into three inferior veins, two of which are again forked. The interno-median vein occupies about one-fourth the entire area of the wing; it gives off three almost equidistant inferior branches, none of which appear to be forked. The anal vein is nearly straight, and has three other almost parallel oblique simple veins occupying the anal area.

The wings of the *Mylacridæ* have the veins spreading in a fan-shape and appearing to arise in a single point, or near a single point, close to the base of the wing. (See Woodcut Fig. 5, *ante* p. 55.)

On comparing our English specimen with Scudder's figures on plate v. of his memoir, already referred to, one is struck with the general likeness they present; but the wings of *Mylacris* seem to be all more complex in the forking of the secondary or branch-veins than in our specimen, which agrees best with Scudder's genus *Lithomylacris*, and with such species as *L. Pittstonianum* (pl. v. figs. 4 and 10 *op. cit.*) or *L. simplex* (fig. 5, *op. cit.*); but our form is certainly distinct from any species figured by Scudder. I have great pleasure in dedicating this *the second English form of Blatta met with by him*, to its discoverer, Mr. James W. Kirkby, of Ashgrove, Leven, Fife, N.B., who has contributed so largely by his researches to increase the fauna and flora of the Carboniferous series of Great Britain.

LEPTOBLATTINA EXILIS, gen. et sp. nov. Pl. II. Figs. 2 and 3.

The species about to be described is represented by two examples, each of which is in a nearly perfect state as regards the greater part of the insect, but neither specimen exhibits the legs (save only a fragment of one). In both specimens there is a portion of the head preserved (more being exposed in Fig. 3 than in Fig. 2).

The prothorax (or pronotal shield) is preserved entire in both, and the meso- and metathorax, followed by ten abdominal segments more or less distinctly to be made out, and having a pair of appendages (*cerci*) attached to the 10th segment in both (but only drawn by the artist in Fig. 3).

Two pairs of wings are seen in both specimens, springing from the lateral borders of the meso- and metathorax, with their outlines fairly exposed (especially so in Fig. 2). The total length of the original of Fig. 2 (which, like Fig. 3, is drawn twice natural size) is 35 mm.

Head.—The head is very small and somewhat bluntly pyramidal in form, and measures 2 mm. in breadth at its base, where it disappears beneath the pronotum, and is 2 mm. in length. There is a suture visible down the centre (in Fig. 3*h*), which divides the two epicranial plates, at the sides of which the eyes would be seen; in front of the epicranium a small projection no doubt represents the *clypeus* with the labrum at its extremity. (This is only indistinctly shown in Plate II., which was drawn and *printed off*, before the final touches of the needle developed these additional points of interest.)

Thorax.—The prothorax, or *pronotum*, is circular in outline in front, the sides being slightly compressed and the posterior border rather incurved near the centre (in Fig. 3); but this incurving of the posterior border is not seen in Fig. 2, so that it may be due to a slight lateral compression of the pronotal shield in the former specimen. In confirmation of this suggestion it may also be stated that the one specimen (Fig. 2) displays no median suture (or ridge) on the shield, whilst the other (Fig. 3), which is incurved on its posterior border, is also distinctly marked by a sharp ridge down its centre. Both specimens display the same indentation around a central pyriform slightly raised, area (similar to that observable on the pronotum in Plate II. Fig. 1).

Length of the pronotum, $7\frac{1}{2}$ mm.; breadth, 9 mm. The mesothorax is about 1 mm. broader than the metathorax; they are nearly of equal length and closely resemble each other in form, being broader in front than behind, and indented upon the lateral margins, to give attachment to the wings. Breadth of mesothorax 6 mm.; length $3\frac{1}{2}$ mm.; breadth of metathorax 5 mm.; length $3\frac{1}{2}$ mm.

The *Abdomen* consists of ten somites; the first is narrower than the rest, and the second is the longest: the whole measure 16 mm. in length, and about 3 mm. or a little more in breadth. There is evidence in Fig. 2 (uncovered with the needle-point, since figuring) of epimeral pieces to the 7th, 8th, and 9th segments on one side, which, repeated on the other side, would add 2 mm. to the breadth of the abdomen, making the total breadth 5 mm. The cerci are 3 mm. in length, the articuli cannot be seen; they are broader in the centre, curved and pointed at the extremities.

Wings.—The wings are remarkably short in proportion to the total length of the body, and the anterior ones are strongly arched along the superior margin. The upper wings measure 11 mm. in length, and the lower or under wings 10 mm. Breadth of upper wings 5 mm., and of lower wings 4 mm.

Owing to some slight difference in the lithological character of the clay-ironstone composing these nodules, rendering them slightly coarser in texture than that which enclosed Fig. 1,—or else, as is more probable, the wings themselves were actually composed of thicker chitine in which the more minute veins were less delicately delineated;—whatever the cause, it is certainly much more difficult to decipher the venation of the wings in these specimens than in the other examples figured above.

We see in the upper wings, or tegmina, of both Figures 2 and 3, one very prominent vein, traversing the whole length of the wing, almost parallel with the superior margin; this is evidently the mediastinal vein. Only the very faintest traces of branches along the superior border of this vein can be detected in Fig. 2, on the right-hand wing. The anal vein can be made out pretty clearly in the wings of both specimens (see Pl. II. Figs. 2 and 3), it extends down to about one-third the length of the inferior border of the wing. The separation of the intermediate area into interno-median, externo-median and scapular, is most difficult to follow. The interno-median

appears to occupy the largest area, and gives off very numerous branches which fork near the margin of the wing. The venation is most distinct upon the under wings, but these, although the most interesting, cannot be seen so fully as the upper ones, being partly covered by the latter.

Detached limb.—Near the extremity of the abdomen of Fig. 3 lie the detached tibia and tarsus of one of the limbs. It can be just made out with its numerous distal segments.

There can, I think, be no doubt that these two specimens from the Dudley Coal-field, which, in the narrow elongated form of the abdominal somites, present so remarkable a divergence from the living Cockroaches, are very closely related to (though probably not specifically identical with) Dr. F. Goldenberg's *Blattina insignis*, figured and described by him in his work, entitled "Fauna Sarepontana Fossilis" (4to. 1873, I. Heft, taf. ii. fig. 14, p. 17), from the Coal-measures of the Skalley Shaft, Saarbrück.

Dr. Goldenberg's *Blattina insignis* has the same general form of the pronotum and wings, and is characterized by the same slender abdominal somites, but it is very much smaller in size than our English specimens; and if reliance may be placed upon the sketch of the venation of one of its wings (sent by Goldenberg to Scudder, and reproduced by the latter author in his Memoir, 1879, *op. cit.* pl. iv. fig. 9), the details of the wings do not agree; but this, like the outline given of the wing itself, may very well be subject to revision.

Mr. S. H. Scudder has arranged all his American *Blattinæ* and also all the old-world forms under new genera, and has placed Goldenberg's *Blattina insignis* with a note of interrogation under *Etoblattina*. This seems waste of energy merely to remove a species from one genus to place it *doubtfully* in another. Now that its characters are more fully revealed to us, it is apparent that its place is not in *Etoblattina*, but in a distinct genus which might be appropriately designated *Leptoblattina*, for the reason sufficiently apparent in the foregoing remarks.

Leptoblattina exilis, like *Etoblattina Johnsoni*, was obtained by the late Mr. Henry Johnson, F.G.S., from the clay-ironstone of Coseley, near Dudley, and the specimens are now, with the rest of the treasures of the Johnson Collection, preserved in the British Museum of Natural History, Cromwell Road, London, S.W.

EXPLANATION OF PLATE II.

FIG. 1*a*. *Etoblattina Johnsoni*, H. Woodw., sp. nov. (nat. size). Clay-ironstone, Coal-measures, Coseley, near Dudley (Johnson Coll.).

,, 1*b*. The same, enlarged twice nat. size, to show venation of wings.

,, 2. } *Leptoblattina exilis*, H. Woodw., gen. et sp. nov. (twice nat. size). Same
,, 3. } locality as Fig. 1 (Johnson Coll.). *h*, head; *t*, pronotum; *ab. abdomen.*

,, 4*a*. *Lithomylacris Kirkbyi*, H. Wood., sp. nov. Bed 33, Upper Coal-measures, Meithil, Fifeshire, from the collection of J. W. Kirkby, Esq.

,, 4*b*. The same wing enlarged twice nat. size.

II.—In Brittany with the Geological Society of France.

By the Rev. E. Hill, M.A., F.G.S.,
Tutor of St. John's College, Cambridge.

THE French Geological Society last year made Finistére the object of their annual excursion, and by their kindness I had the great pleasure of joining the party. As Brittany is so interesting a region, already very accessible by railways, and soon to become even more so, it has occurred to me that a brief account of the excursion may be acceptable to our English geologists, and at any rate afford them an index to some localities which will well repay a visit.

It will be convenient to preface with a table of the strata, according to the nomenclature and classification of Dr. Barrois.[1] He arranges the beds of this region as follows:

Carboniferous.

Coal-measure Schists and Conglomerates.
Schists and Sandstones of Chateaulin.
Porphyrite Tuffs.
Porphyry Conglomerates and Tuffs.

Devonian.

Nodular Schists of Porsguen.
Schists and Limestones of Néhou.
White Grit of Landevennec.
Schists and Quartzites of Plougastel.
Limestone of Rozan (with *Strophomena Looiensis*).

Silurian.

Nodular Schists (with *Cardiola interrupta*).
Ampelite Schists (with Graptolites).
White Sandstones.
Slaty Schists of Angers.
Armorican Grits (Grés a scolithes).
Red Conglomerates and Schists of La Chevre.

Cambrian.

Schists and Conglomerates of Gourin.
Phyllades of Douarnenez (or of St. Lo).

Primitive.

Schists of Groix.
Mica-Schists of Audierne.
Granitic Gneisses of Pont-Scorff.

Dr. Barrois regards the Cambrian Schists of Gourin as corresponding to Barrande's Etage C; any identification of the beds below must at present be conjectural.

Among the eruptive rocks the granite of Pontaven is Cambrian or Pre-Cambrian; the porphyroid granites of Rostrenen and Huelgoat are of Carboniferous age; the granites with two species of mica (granulites) of Quimper, Le Faouet, and Morlaix, are also Carbon-

[1] See "Aperçu sur le constitution géologique de Finistére" in the June number of "Le Guide Scientifique" (Paris, J. Michelet, 25, Quai des Grands Augustins; London, J. A. Berly, 3, Deronda Road, Herne Hill, S.E.).

iferous and posterior to the last. The kersantons cut the (Carboniferous) Chateaulin schists and are the latest of the eruptive rocks.

Quimper was our rendezvous. On the afternoon of Aug. 19, after the first meeting, a stroll was taken along the promenade on the left bank of the stream to look at outcrops of 'Petrosilex' seen there. This is much crushed and a confident opinion on it is not easy to form. Then walking out of the town to the west, we saw, first in the town a conglomerate of Carboniferous age, then successively along the high road a coarse white gneiss, a mica-schist well exposed in a road cutting, finally a granite. These rocks are said to occur in this alternate fashion over a vast tract of country. Returning, we deviated a little to examine a diorite dyke.

Proceeding by rail to Chateaulin, we commenced the next day by examining the schists of Chateaulin here worked for slates. They closely resemble the slates (also of Carboniferous age) of Vernayaz and Salvan (Switzerland). No fossils occur here; the position of the rocks is established by a few impressions found in some limestone beds towards the base of the series. At Port-Launay below Chateaulin a steamer was waiting, placed at our disposal by the Port Admiral of Brest, and embarking, we commenced our descent of the river. After some hours of pleasant transport and pretty scenery, a landing was made on the right bank near Terenez, where the quartzites of Plougastel are exposed, and where the grits of Landevennec can be seen to succeed them conformably. We walked along the strand for a mile or two, and found our boats waiting to re-embark the party nearly opposite Landevennec.

The boats again transferred us from the steamer to the shore in the Riviere de l'Hopital, at the spot on the right bank marked as Moulin de Mer. There is a tide mill here, whence the name, with large and good machinery; a breakfast spread in a spacious loft was very welcome. East of the mill and behind it is a fine quarry of kersanton and porphyry. The schists of Néhou are here cut by a mass consisting of kersanton between two bands of porphyry, but the relative age of these two igneous rocks can be determined better by a section described below. From Moulin de Mer, walking west through Logonna and seeing at an estuary the schists of Porsguen, we collected the rare rock quartz-kersanton in a rocky beach at Goulet-quer, and were again put on board the steamer. Kersanton, so frequent in this district, was named after a shallow quarry in this neighbourhood, now, however, disused and overgrown.

We were landed for the last time this day, about three miles to the N.N.W., at a promontory near Porsguen, to see a most beautiful section. It is in the sea-cliff on the east side of the promontory, and shows the schists of Porsguen, porphyry (micro-granulite) overlying them, and a dyke of kersanton breaking through both. The black sedimentary rocks are little altered, but tremendously crushed by this double intrusion, and show a rude cleavage set up across the old fissile bedding. Time not allowing a purposed visit to the Isle Longue, our steamer took us through the vast landlocked gulf that is called Brest Roads (Rade de Brest) direct to the quay at Brest itself.

On the following day the same steamer, again devoted to our service, carried the party south across the Roads to a little pier at Le Fret. Vehicles were ready, but as soon as they had taken us across the embankment to the S.E., we left them and walked along the strand eastwards, to see the outcrops of the schists of Porsguen and to collect Devonian fossils at a spot about 300 yards from the road. Returning, we were driven through Crozon across the isthmus to a very lovely bay, combining the broad beach of Sandown with the tall cliffs of Ilfracombe, and possessing every qualification for a watering place except accessibility. A good hotel is named from the neighbouring village of Morgat; and this name is the one used by geologists in referring to the cliff-section, the most complete which we saw in the excursion. We commenced by walking to the south, to see in succession the Schists with Graptolites (fossiliferous); the slates of Angers; the Gres Armoricain or Gres a Scolithes fossiliferous about 100 yards above the pier of the little fishing port; and (if time had permitted) the Red schists of Cap de la Chevre which form the base of the Silurians here. The succession is clearer on this side than on the north side of the bay. Returning and passing along the upper edge of the cliffs, we traversed repetitions by several folds of the complete Silurian system with part of the Devonian, as high as the quartzites of Plougastel, which here form some of the most striking cliffs. After walking three or four miles, and crossing by an embankment the estuary called Aber to Rosan, we were shown at the neck of the peninsula that forms the Isle d'Aber, a singular series of stratified diabase tuffs. They are placed by Dr. Barrois between the uppermost Silurian and lowest Devonian beds (Schistes a Nodules and Calcaire de Rozan). Proceeding along the cliffs past Kerglintin and further east some two miles or more, where the path passes along a cliff slope, we saw the Gres a Scolithes succeeded by the Red schists, and these passing down into a singular quartz conglomerate so veined with quartz that I was slow in being convinced of its true nature. Then descending into the little bay, we saw rocks of an entirely different aspect: the Phyllades of Douarnenez belonging to the Cambrians; and the few active geologists, who, after so long and rapid a walk on a broiling day, were 'in at the death,' threw themselves down on the sand and commenced a lively discussion on the evidences of the succession, which my knowledge of French was insufficient to follow. The carriages were waiting for us as Tal-ar-groes, about three miles to the N.W., and took us to our steamer, which brought us back to Brest. We arrived at so late an hour that, had the rules of entry into a fortified town been strictly carried out, we should have had to dispense with supper and bed.

After a morning of rest, an afternoon of railway back through Chateaulin and Quimper took us to Quimperlé. Next day we started early for a very interesting excursion. Crossing at first gneiss with an intrusion of 'granulite,' we drove west as far as Pontaven. Here about one kilometre to the south, on the left bank of the river, we examined in shallow quarries the granite of Pon-

taven, supposed to be of Pre-Cambrian age. The granite is not perfectly homogeneous, but has some faint appearance of structure or incipient foliation, and I noticed a seam that to me resembled a line of crush. Scattered masses tend to weather into oval boulders. North of the village, a short distance on the right bank, we saw granite closely followed by a much contorted rock; a gneiss or mica-schist in contact with the granite. This gneiss is regarded as rather later than that of Quimperlé.

Returning as far as Riec, and then diverging south-east, we passed rocks of varying nature, named as sometimes granitic gneiss, and sometimes gneissic granite, till where a new road has been made for a mile or two skirting the estuary of the Belon, a series of fine sections are furnished. Any geologist interested in the question of mica-schist and gneiss originating out of igneous rocks should especially study the sections in a cutting which succeeds an embankment made for the road.

Thence we drove through Moelan and Clohars to the mouth of the river Ellé, from Quimperlé, and descended to the sandy beach at Port Clohars (gay with bathers, country people, the tourist is unknown). Here the cliffs to the east afford fine exposure of a succession of stratified rocks regarded as Pre-Cambrian in age. Some are hornblende schists, fairly compact; some are extremely coarse-grained rock, that seemed to me an arkose of a coarse gneiss, and are by no means highly indurated: there are also some quartzite beds, and some chlorite schists, besides an intrusion or two. These beds recur in similar order, so that there are probably repetitions by faults; unfortunately I had not time to study this most interesting section, and had to be satisfied with viewing it in a simple traverse. We rejoined the carriages at St. Julien, and returned to Quimperlé, obtaining good specimens of the Quimperlé gneiss (gneiss of Pontscorff), after passing under the railway, at the entrance to the town.

On Tuesday morning our procession of vehicles defiled from the town to the north-east along the road to Le Faouet. Granite was examined at Le Combout, but nothing remarkable was seen till when, within two miles of Le Faouet, we left the carriages and passed the very interesting church of St. Fiacre. Making our way eastwards by footpaths we came out on another high road, near the mill of Rochepierou, to view the (Cambrian) Phyllades of St. Lo, at or near their junction with a granite (granulite): the only sections are small roadside outcrops. Thence we walked to Le Faouet, which was made a lively scene by the occurrence of a fair that day. Between this place and Gourin 'granulite' is passed at Pont du duc, and a rather fine-grained granite at Le Saint. Gourin is said to be the critical point for deciding on the conformability or otherwise between the conglomerates of Gourin and the phyllades of St. Lo; but the evidence is I believe only circumstantial. Grey schists are well seen near a rivulet just before entering Gourin, and the conglomerates in a quarry about $1\frac{1}{2}$ miles east of the town on the road leading to Plouaray. We again saw the red conglomerate north-

east of the town, and then a section of the Schistes d'Angers. The road gave some good scenery in its traverse of the low ridge called the Montagnes Noires, but whatever else of interest there may be between these and Carhaix was lost in the shades of evening and night.

Two days were spent at Carhaix, occupied by two long excursions eastwards to Rostrenen and Goarec respectively, to study the phenomena of metamorphism on each side of the great intrusion of the Rostrenen granite. Deviating from the direct road to pass through Paule, we were there shown the first signs of alteration in (Carboniferous) Chateaulin schists. Near Glomel the change had gone further, and small but perfect crystals of andalusite had been formed. We walked about two miles west of Glomel on a road, and then turning north down a lane about half a mile collected in a quarry near Bressillion andalusite in altered (Devonian) schists of Plougastel, thence returning south-west and south, saw near Kervennan the same mineral developed in the (Silurian) schists of Angers, while at Rostrenen itself, just outside the village, we collected the beautiful porphyritic granite that is the agent of all this change. The porphyritic crystals of felspar reach a large size, and in decomposed rock they lie as pebbles in a sand. To the south of the village, in a large rock on the side of the road, near Kerbescont, the schists of Plougastel reappear altered into leptinolite.

Beyond Rostrenen (this was on the second day), about the kilometre stone marked 17, a fragment of schist is seen actually included in granite; further on, sandstones belonging to the Chateaulin schists occur little altered, and about one mile before reaching Plouguernével, a small excavation on the road-side shows an actual contact; a mass reposing in a trough of the granite, with an isolated piece completely surrounded. Further on, they are seen again in a pit with a pond, less altered as being further from the granite.

At Goarec, at the east end of the village, on the north side of the road, is a quarry in a rock unlike anything we saw elsewhere, and said to resemble the Porphyroides of the Ardennes. It is supposed to pass into the schists, but its relations are not seen here. South-east from Goarec along the high road the Schistes d'Angers are seen in fine crags. Quitting the route at Bon Repos, and denying ourselves more than a distant glance at the picturesque abbey, we crossed the canal and entered on an extensive wood. After following the canal bank a mile or more, we turned south to reach the abandoned Forges des Salles, just beyond which in the wood is a quarry in some highly cleft 'schistes a chloritoid.' On the roadside three or four miles further (east side, just before the group of houses called St. Brigitte), is a shallow quarry in a kind of slate, which while showing only traces of cleavage, and containing fairly abundant and quite recognizable fossil impressions (Trilobites, *Orthis*, etc.), is also full of fine crystals of andalusite, which lie in the closest proximity to the fossils.

Quitting Carhaix on the 27th August, and driving to the N.W., cuttings made for the road show sections of Chateaulin shales with

some indistinct remains of plants. Beyond Poullaouen are some fine dykes of kersanton, and further on a small one of micro-granulite; thus intrusions of both these rocks must have been going on as late as in Carboniferous times. For the kersanton, there is some evidence that it did not occur earlier; no pebbles of it are found in conglomerates which include all the other igneous rocks; as for instance at about four kilometres before reaching Huelgoat, in a conglomerate belonging to the base of the Carboniferous series. In a quarry about a mile from the road, at Bruguec north of Kerrion, a microgranulite tuff again proves that the eruptions of this rock towards the end of the Devonian age continued into the Carboniferous.

The mine of Huelgoat has had a long and interesting history, but now is abandoned. In the walls near it are a few fragments of the Roche Verte, a green breccia, which has been the subject of much discussion, but is now considered to be a bed below the Chateaulin schists, and above those of Porsguen (Porphyrite tuffs of the Table). From beyond the mine a path leads for some miles through a beautiful wood by the bank of a water channel at a high level on the hill-side to the quaint little town of Huelgoat.

The porphyroid granite of Huelgoat resembles that of Rostrenen, and belongs to the same (Carboniferous) age. The great rocking stone called the Roche roulante, distant about half a mile, is worth a visit, and just below it is a quarry in the granite which there contains abundantly pinite. Thence we regained the Carhaix road, and returned along it some two kilometres to the east to see the contact of the granite with Porsguen schists. A dyke of microgranulite cuts the granite a little before reaching the junction. The schists are indurated into a rock which has been called Cornien, and the alteration is certainly considerable. We turned north along the main road towards Morlaix to reach, after 3 or 4 kilometres, a long shallow quarry in quartzites of Plougastel, here altered by the granite, and went about a quarter of a mile up a footpath (not marked on the map) to Le Vern for schists of Angers rendered crystalliferous. At An Avallennou on the high road, the Grés a Scolithes is seen little altered. We returned a few hundred yards and took a lane to the south-west, which soon led us over the granite. After some three kilometres it brought us out at Ty le Brennou, where Plougastel schists are seen at their contact with the granite, and where a quarry in a field west of the high road gives a beautiful section of the junction. This completed for the Huelgoat granite what had been done on the previous days for the Rostrenen granite, an examination of the effects produced on all the beds broken through. The parallel bands of strata which cross the country from east to west are in each case interrupted by the great intrusion, and the resulting alteration in each case surrounds the igneous mass as a sort of aureole or halo, intensest at the boundary and dying away at a mile or so from it.

Our last day was devoted to the neighbourhood of Morlaix. In the morning we drove southwards along the road which leads at first south-west from the centre of the town (past the post-office). About a mile from the town, and a quarter of a mile east of the road (at

Buvette a Pont Neuf), a moorland hill affords a few Devonian fossils in a grit belonging to the schists of Morlaix. Further along the road occur schists of Plougastel altered by granite (of Pompol). A quarry on the west side of the road, about two miles from the town, shows garnets and chloritoid in the altered schists. About a mile further, in another quarry about 100 yards west of the road, behind some houses (Le Fume?), the schists have become leptinolite. The road-sections, a little beyond, of granite tongues running into schists, are as fine as I ever saw.

An afternoon excursion from Morlaix took us a circuit north of the town. We passed on the right bank of the river singular bedded rocks (Schists of Morlaix), with a granite dyke cutting them, and made deviations to see the quarry of Kerscou and its wonderful junction of granite and schist (a strip of black shale, 30 feet long by 18 inches broad, is included as if torn off), and at a hamlet called Ploujean a unique porphyry dyke. Thence regaining the main N.N.E. road we passed in a valley a diabase dyke badly seen in road-sections, followed by some conglomerates, and arrived at the head of the estuary of the Dourdu, where, by walking half a mile along the northern strand, we were to have seen a limestone conglomerate; but a tide of phenomenal height obstinately continued to rise and entirely barred our progress. Quartz conglomerates were again seen in the road along the slopes above, and about the 5 kil. stone from Morlaix, in shallow quarries for road metal, the Grès a Scolithes. Thence returning through St. Antoine, and driving east for several miles, we traversed the whole basin of the Morlaix schists, until we again encountered the Grès rising from under them. In a shallow quarry in the midst of fields, and almost buried from sight, we were shown the locality where a few rare fossils have proved its Cambrian age. This ended the excursion.

The guiding idea in its arrangement was to show first the complete series of unaltered beds, and afterwards the modifications which these rocks present around the invading masses of granite. I cannot attempt to reproduce in any way the interesting discussions on these phenomena which occurred between the distinguished geologists of the party. From my own observations I come back with the strengthened conviction that it was no causes of this kind which gave origin to the crystalline schists.

I desire to take this opportunity of expressing my gratitude to the members of the party, and especially to its President, Dr. Barrois, both for the opportunity of joining the excursion, and for the particular kindness and attention bestowed on me at every possible occasion.

III.—Note on Specimens of the Rauenthal Serpentine.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S.

IN the very valuable work on "British Petrography" by my friend Mr. J. J. H. Teall, now in process of publication, there is a rather full notice of an interesting serpentine which occurs in

the Rauenthal (Vosges), and has been investigated by Herr Weigand.[1] According to the latter author, as summarized by Mr. Teall,[2] this serpentine "has been formed by the alteration of a hornblende rock, and the change has been accompanied by the removal of lime and the development of a chlorite, in which the original alumina of the hornblende is retained."

Such an origin for a serpentine would of course be perfectly possible, supposing that a certain amount of silica was also removed; for the formation of the mineral serpentine from malacolite and other non-aluminous varieties of pyroxene is familiar; but inasmuch as masses either of pure hornblende or pure pyroxene[3] are certainly very rare, we should expect such a serpentine to be extremely local in its occurrence, and (like the pyroxene-serpentine) rather abnormal in aspect. Hence it will be well for the student of "British Petrography" to remember that, if Herr Weigand be correct, the origin assigned to the Rauenthal serpentine is not likely to interfere with the general rule that normal serpentines result from the alteration of peridotites. But is Herr Weigand quite correct, and does not his statement require a little limitation? I confess that his paper has awakened some suspicions in my mind which are confirmed by the examination of specimens, procured by Mr. Teall from Stürtz of Bonn, and by him kindly placed at my disposal.

First, as regards the results of Herr Weigand's studies of the rock. In his paper, which is a most conscientious piece of work, he gives us, in addition to an analysis of the white mica-like constituent—a chlorite—an analysis (A) of the soluble portion of the rock (*i.e.* practically all but the chloritic constituent, not generally abundant), a bulk analysis (B) of the whole rock, and an analysis (C) of the amphibolite into which the serpentine is said to pass. These are as follows:—

	A.	B.	C.
SiO_2	37·706	36·944	46·407
Al_2O_3	0·201	1·353	6·727
Fe_2O_3	10·428	6·868	4·649
FeO	——	3·956	2·107
CaO	1·677	1·393	10·642
MgO	36·602	36·022	26·252
H_2O	13·386 (diff.)	13·089	3·584
	100·000	99·625	100·368

Now a glance at A and B shows that either the one or the other would be a very fairly normal analysis for an ordinary serpentine.[4] As usual the silica and magnesia are nearly equal in amount; there is about the ordinary proportion of iron oxides and water. The percentage of lime, though not large, would lead us to suppose that augite or hornblende rather than enstatite had been

[1] Tschermack, Min. Mitt. 1875, p. 175. [2] British Petrog. p. 112.

[3] I find that the diallage rock at Lendalfoot, described by me, Q.J.G.S. vol. xxxiv. p. 778, is not quite free from olivine. This too is a comparatively small mass.

[4] That is to say, a rock which has resulted from the alteration of a rock consisting of olivine with a certain amount of a magnesian bisilicate. A serpentine formed from a perfectly typical dunite should have MgO in excess of SiO_2.

associated with the dominant olivine of the original rock, that is, that it had been one of the varieties of peridotite, which approach nearest to picrite, and by some would even be included under that name.[1] If we can take the amphibolite as in any way representing the parent rock of B, we see that not only must we remove a considerable amount of lime (almost enough, so far as figures go, to make up the difference in water), but we must get rid of a considerable proportion of alumina, and a large amount of silica.[2]

If these substances have been removed, it is a little strange that we do not find traces of them in the form of veins and similar deposits in the rock itself. But Herr Weigand does not mention any, and I find none in the specimens before me. It may, however, be objected to this mode of reasoning, that the amphibolite does not fairly represent the rock from which the serpentine (B) was formed, but only a rock which was closely related to it; and, having regard to the "badly mixed" condition of many of the basic igneous rocks—such as the peridotites and picrites—the objection is not unreasonable. Let us then see whether the difficulty would disappear if we were dealing with some other variety of hornblende rock. Clearly we must select as its constituent mineral a hornblende poor in alumina, rich in magnesia. In all the analyses quoted by Dana in his Mineralogy, the percentage of silica (as we should expect in a bisilicate) is greatly in excess of magnesia. Even antholite, which, by its richness in iron and poorness of lime, would be the most suitable constituent of the mother-rock of the Rauenthal serpentine, has at most $SiO_2 : MgO = 584 : 314$.[3] Thus a consideration of Herr Weigand's analyses alone suggests that either the specimens analyzed or the specimens examined microscopically were abnormal, or there had been some slight error in the one or the other investigation.

I proceed now to the result of my own examination of Mr. Teall's two specimens. Slides have been cut from each, two from one (that which he kindly gave me), one from the other. After careful study of these, while I agree with Herr Weigand that the original rock has contained a variety of hornblende, and that some of this has been altered into a serpentinous mineral, I can come to no other conclusion than that the dominant constituent in each is a serpentine formed from olivine.

On examining one of the slides cut from my specimen,[4] we see that it is chiefly composed of two constituents rather irregularly dis-

[1] For myself I think it better to apply the term *picrite* to the rather indefinite group which is intermediate between the true peridotites (or felsparless rocks where olivine dominates) and the olivine-dolerites. Olivine + augite and olivine + hornblende need names.

[2] Suppose, for purposes of comparison, we assume that no magnesia has been removed. In (B) $Al_2O_3 : MgO = 14 : 360$; in (C) $Al_2O_3 : MgO = 67 : 263$. These proportions expressed in decimals are ·038 and ·254. Again in (A) $SiO_2 : MgO = 369 : 360$—almost equal; in (C) $SiO_2 : MgO = 464 : 262$—about 17 : 10.

[3] Anthophyllite would also be a very suitable mineral, but it is evident that we are not dealing here with a rhombic mineral, but one which much resembles tremolite.

[4] These happen to be slightly thicker than Mr. Teall's slide, so that the distinction of the constituents is rather more conspicuous.

tributed. The one—almost colourless—clearly is or has been a hornblende, as described by Herr Weigand. It shows, even when converted into serpentine, the characteristic cleavages parallel to ∞ P in cross-sections and the parallel lines formed by these in longitudinal sections. Occasionally portions of the mineral still remain unaltered. The other constituent is a pale sap green in colour; it consists of a rather irregular network of a doubly refracting mineral, with interspaces chiefly occupied by an isotropic mineral. This meshwork can be readily seen by transmitted light, but is rendered more distinct by using crossed Nicols, when the 'strings' appear either white or pale golden yellow. This structure, and this mineral or association of minerals are perfectly familiar to me as the result of the alteration of olivine; there are various minute structural differences between the isotropic parts of this and the most highly altered portions of the other mineral, which it is almost impossible to describe without entering into details which would be tedious, but which become readily apparent to a practised eye after a little study, so that while I will not undertake to say that I can distinguish every grain of the two constituents, I have no hesitation as to distinguishing them in at least five-sixths of the rock. Hence I cannot admit the general accuracy of my friend's statement, founded upon Herr Weigand's paper: "Microscopic examination shows that the rock differs markedly from normal olivine serpentine. It consists of a transparent green or colourless substance,[1] in which the irregular 'maschenstructur' due to the separation of the iron oxide along the original cracks of olivine is absent." But the "maschenstructur" of a serpentine derived from olivine is not *due* "to the separation of the iron oxide," but "to the original cracks" (*i.e.* the imperfect cleavage planes) of the mineral itself. It is, indeed, very commonly exhibited in great perfection by the deposition of iron oxide, which plays the part of an injection in an organic structure; but it is quite a mistake to suppose that the iron oxide is *always* separated and deposited in this way.[2] The 'mesh structure' in the Rauenthal rock is not seldom divided down the middle by a line (indicating the original cleavage plane); this is sometimes made more distinct by a slight deposit of iron oxide, and the minuter structures of these strings agree perfectly with those in a normal serpentine. Thus the above-quoted sentence would be more correctly worded as follows:—"It consists of a transparent green *and* a colourless substance," and the remainder of the sentence would then apply to the latter of these, viz. the altered hornblende. As to the relative amounts of the two minerals, it is difficult to speak exactly, as they are rather irregularly mixed; but in no case, I think, does the hornblendic constituent dominate in the field of view under a one-inch objective, and on the

[1] I observe that very commonly there is a slight green band between the cracks (cleavages) of this mineral, as though a liquid had been injected from without. I have noted the same thing in the case of the pyroxenic minerals present in other serpentines. The mineral may be derived from the olivine and "injected" during the hydration of the olivine, which process must set up considerable strains and pressures.

[2] See, for instance, Wadsworth's Lithological Studies, pl. iv. fig. 4. The decided green colour is probably due to imperfect separation of the iron.

whole I have no doubt that in my slides the peridotic constituent is distinctly in excess. Hence either our specimens are exceptional, or Herr Weigand has examined slides cut from an exceptional specimen, or he has failed to distinguish the two minerals. So far as I can form an opinion from the woodcut given in his paper, I confess that I incline to the last solution, for I think that even there I can see indications of a difference in the constituents. In any case it is, I think, clear, that the Rauenthal serpentine is only a variety of the group of serpentines derived from the alteration of olivine-hornblende rocks, of which we have excellent examples at Mullion, Pradanack, and other localities at the Lizard.[1] To some of these indeed the Rauenthal rock has, both macroscopically and microscopically, a considerable resemblance. All that we can assert is that occasionally (possibly) the white hornblende is rather exceptionally abundant, and that (as sometimes occurs elsewhere) a peculiar variety of chlorite is locally developed.

I may take this opportunity of calling attention to another statement on p. 119 of Mr. Teall's work, which I believe to be not quite accurate. Speaking of the occurrence of felspar in the Lizard serpentines, Mr. Teall says, "It is present also in slides of a variety of serpentine from the Rill Head, near Kynance, lent to the author by Mr. Waller," to which he appends the note, "The author has recently visited the district and ascertained that serpentine containing felspar forms a large portion of the Rill Head. The original rock, therefore, was of the nature of a picrite." It would not, of course, be surprising if a little felspar occurred in a mass of serpentine, and I had already noticed at Gue Graze (on the same coast further to the north) a decomposed mineral which I thought might be felspar, as is mentioned by Mr. Teall in the passage from which I have quoted, though it would be more correct to say, "Professor Bonney records it (felspar) as [probably] occurring at Gue Graze," as will be seen on reference to my description of the Gue Graze rock (Quart. Journ. Geol. Soc. 1877, p. 918). But in regard to the Rill rock I do not consider the mineral mentioned by Mr. Teall to be felspar. No doubt it occasionally closely resembles a plagioclastic felspar, both in its earthy decomposition and its lamellar twinning; but after carefully examining my own slides (including one cut from a specimen kindly given me by Mr. Teall, and one which Mr. Waller freely placed at my disposal, I am distinctly of opinion that the mineral is not felspar. This earthy decomposition (which weighed much with me in examining the Gue Graze rock) is, I now find, not unfrequent in colourless minerals belonging to the pyroxene group, and the mode in which the transparent parts of the crystal are attacked appears to me to be different from that in which kaolinization proceeds in a felspar. There are also some minute structural peculiarities in the mineral, which to my eye recall a member of the above-named group and not a felspar. The twinning, which however is not very common, is no doubt curiously like that of a plagioclastic felspar; but similar twinning does occur, though rarely in augite or diallage (Fouqué and

[1] As mentioned in my paper, Q.J.G.S. vol. xxxix. p. 23.

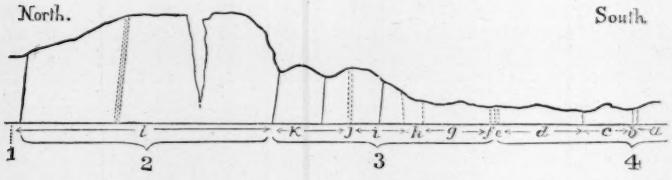
Lévy, Roches Eruptives, p. 358). Hence I feel convinced, after repeated examination, that the presence of felspar in this Rill rock cannot be asserted on the evidence before us, and that it consists chiefly of olivine (more or less altered into serpentine) and augite (diallage). Further north the pyroxenic constituent appears to be commonly a colourless hornblende. It is possible that this mineral is also present in the Rill rock, and I think I have detected a grain or two of rhombic pyroxene.

IV.—On the Discovery of the *Nummulina elegans* Zone at Whitecliff Bay, Isle of Wight.

By H. Keeping,
of the Woodwardian Museum, Cambridge.

WHEN visiting Whitecliff Bay, Isle of Wight, last September, I was so fortunate as to find exposed on the shore at low-water, the whole of the various strata from the Brook Bed of the Bracklesham, to the Bembridge Limestone inclusive. I have visited this locality many times, but have never before seen the Barton Series exposed. On my return to Cambridge, I mentioned the subject to Prof. Hughes, and he suggested that I should make another visit in order to obtain a larger collection of fossils; but on this second occasion, I was surprised to find that the whole of the strata, which I had seen on the shore in September were now covered with sand to the depth of twenty inches. Therefore, seeing that nothing could be done on the shore, I set to work at the cliff, and succeeded in finding the same beds there.

For the sake of reference I have copied a part of Professor Prest-



1. L. Headon. Brockenhurst Bed. 2. Upper Bagshot. 3. Barton Series. 4. Bracklesham Series.

Section in Whitecliff Bay, Isle of Wight.
Scale 1 inch = 150 feet.

wich's [1] section, which I consider so good that it would be difficult to improve upon it, except by adding details of zones since discovered: these are shown by the dotted lines. In ascending order

[1] On the Tertiary Formations of the Isle of Wight, Quart. Journ. Geol. Soc. vol. ii. p. 223, plate ix. 1846.

the beds seen, commencing with the Brook Bed of Bracklesham, are as follows:—

(*a*) Brook Bed.

(*b*) Grey sandstone or Tellina bed of Selsea.

(*c*) *Nummulina variolaria* zone, measuring about 20 feet, being quite full of these small Foraminifera.

(*d*) Dark green sandy clays, with glauconite grains. This part of the series I consider to be the equivalent of the beds just above the *Nummulina variolaria* zone of Stubbington and Hunting Bridge in the New Forest, which has been described by the Rev. O. Fisher.[1] I could find no fossils sufficiently well preserved for identification in this part of the series. Thickness about seventy feet.

(*e*) A thin band of dark earthy-coloured sand, rather coarse: this I did not find on the shore at low-water, where, however, I have no doubt it occurs. *Ostrea flabellula* is fairly abundant in it. The thickness is seven inches.

This brings us to the bottom of the *Nummulina elegans*[2] zone, which therefore is now shown to be of such wide extent and constant occurrence that it seems more convenient to adopt the Rev. O. Fisher's[3] classification, and take this horizon as the basement of the Barton Series.

(*f*) *Nummulina elegans* zone, consisting of rather dark green and blue glauconitic sandy clays, much crowded in places with *Nummulina elegans*. I was much interested in finding this rich bed for the first time in this locality, as the Bracklesham and Barton Series have not been found before in juxtaposition with sufficient fossil evidence. There cannot now, however, be any doubt of the existence of the Barton as well as the previously known Bracklesham at Whitecliff Bay, as at that locality the fossils give abundant evidence of the existence of each. The following are the fossils from the *Nummulina elegans* zone, which has a thickness of thirteen inches:—

Typhis pungens, Brand.
Fusus bulbus, Brand
Cominella Solandri, Edw.
Pleurotoma exorta, Brand.
Voluta luctatrix, Brand.
——— *digitalina*, Lam.
Mitra parva, Sow.
Calyptræa trochiformis, Lam.
Dentalium striatum, Sow.
Bulla, sp.
Corbula pisum, Sow.
Crassatella sulcata, Brand.
Cardium semigranulatum, Sow.
Leda minima, Sow.
Ostrea flabellula, Lam.
Nummulina elegans, Sow.

The specimens of *Nummulina elegans* at Whitecliff Bay are, I think, somewhat finer than those at either Alum Bay or Highcliff.

(*g*) Pale blue and yellow sandy clays, with very few and badly preserved fossils. Thickness, 54 feet.

(*h*) A stiff laminated clay, with occasionally dark patches. Few or no fossils. Thickness, 18 feet.

[1] Quart. Journ. Geol. Soc. vol. xviii. 1862, p. 65.

[2] Formerly called *N. Prestwichiana*, but the recent researches of Prof. Rupert Jones prove it to be *N. elegans*. See his paper read before the Geological Society, December 15th, 1886.

[3] *Op. cit.*

(*i*) Grey and pale blue clays, with light fawn-coloured bands near base. Thickness, 36 feet.

(*j*) Imperfect ironstone band not well seen. Thickness, 3 feet.

(*k*) Blue sandy clays, with mottled brown patches of soft earthy ironstone near the base. Thickness, 50 feet, the upper fifteen feet of which consists of a bluish sandy clay, and contains the following fossils:—

Terebellum sopitum, Brand.
Voluta humerosa, Edw.
Pyrula nexilis, Lam.
Natica, sp.
Calyptræa trochiformis, Lam.
Ostrea flabellula, Lam.
Pecten carinatus, Sow.
——— sp.
Lima, sp.
Avicula media, Sow.
Arca, sp.
Pectunculus deletus, Brand.
Limopsis scalaris, Sow.
Nucula bisulcata, Sow.
Chama squamosa, Brand.
Cardium porulosum, Brand.
Lucina gibbosula, Lam.
Crassatella tenuisulcata, Edw.
Cypricardia sp.
Cardita oblonga, Sow.
Cytherea tenuistriata, Sow.
Tellina ambigua? Sow.
Corbula ficus? Brand.
Panopæa intermedia, Sow.
Shizaster D'Urbani, Forbes.
Ditrupa plana, Sow.

For the convenience of collectors, I give the following measurements taken along the cliff at high-water, commencing with the Bracklesham Sandstone, which can always be seen, so that the strata under consideration can be found at any time:—

Bracklesham Sandstone to the *N. elegans* zone	126 feet
N. elegans zone to top of Barton	161 ,,
Top of Barton to top of Upper Bagshot	186 ,,
Lower Headon	19 ,,

The Whitecliff Bay section is almost complete from the Chalk to the top of the Bembridge Series, as it not only shows a good exposure of Barton Clays, but also the Brockenhurst and Roydon zones (Middle Headon). It is therefore by far the most perfect section of the Tertiary formation in England.

I am indebted to Prof. Rupert Jones for examining the specimens of *Nummulina*, both from the Bracklesham and Barton Series; he considers *N. elegans* to be the only species found in the Barton, the so-called *N. variolaria*, found some forty feet above the true *N. elegans* zone, being only a thickened form of *N. elegans*. There seems, therefore, to be only one species in the Barton and two in the Bracklesham Series.

It will be seen that a few of my measurements differ slightly from those given by Professor Prestwich: this is due to the latter having been made along the cliffs, while mine were taken on the shore at low-water.

The specimens referred to in the above paper are preserved in the Woodwardian Museum, Cambridge.

V.—Note on the Gault and Chalk Marl of West Norfolk.

By A. J. Jukes-Browne, B.A., F.G.S., and W. Hill, F.G.S.

UNTIL the appearance of the article by Messrs. C. Reid and G. Sharman in the Geological Magazine for February, 1886, p. 55, no one had ever thrown a doubt on the existence of true Gault

in Norfolk. The grounds on which these gentlemen venture to doubt its existence are these :—

(1) No clear line of separation between the Gault and Chalk Marl, and no phosphatic bed marking the base of the latter, could be found by the Geological Surveyors.

(2) They give a list of unphosphatized fossils from the marly clay of West Dereham, which they regard as a Chalk Marl fauna.

(3) The phosphatic casts of Gault species they regard as derived fossils.

From these premises, and without any attempt to determine the horizon of the Totternhoe Stone, which would fix the upper limit of the Chalk Marl, they come to the conclusion that the whole of the so-called Gault in Norfolk is Chalk Marl, and not really Gault.

We have recently endeavoured to follow the subdivisions of the Chalk through the western parts of Suffolk and Norfolk, and having visited the localities mentioned by Messrs. Reid and Sharman, we wish to record our entire dissent from their conclusions, and to give our reasons for maintaining the existence of Gault in West Norfolk.

(1) In the first place we found that the upper part of the Chalk Marl changes its character as it is traced northwards, and becomes a hard greyish chalk, passing, in fact, into the "hard chalk," which Messrs. Reid and Sharman speak of as resting upon "the Chalk Marl." At Stoke Ferry, twenty-two feet of this hard "Chalk Marl" is exposed below the representative of the Totternhoe Stone; its full thickness is probably about thirty feet, and between it and the level of the springs on the border of the [Gault] clay plain, there may be ten or fifteen feet of soft Chalk Marl. Now the width of the clay plain near West Dereham is about two miles, and an easterly dip of only 1° would give a thickness of fifty-nine feet. That this calculation is within the mark is proved by a boring at Wretton, west of Stoke Ferry, the particulars of which were obtained by Mr. Whitaker, and which gives a thickness of sixty feet of clay at a spot which is certainly below the summit of the clay. If, therefore, the whole of this clay is to be referred to the Chalk Marl, we must add it to the thickness of the overlying beds above mentioned in order to get the total thickness of this stage; doing this we obtain a minimum of 100 feet, and a possible thickness of 120 feet for the Chalk Marl of Norfolk. Near Cambridge its thickness is about sixty feet, and we are therefore asked to believe that it has expanded to double its thickness in a direction in which all the beds are evidently and admittedly thinning out.

(2) In the next place we cannot allow that the assemblage of unphosphatized fossils obtained from the clay is such as to merit the name of a "Chalk Marl fauna." Nearly all of them are species which range from the Gault to the top of the Lower Chalk, and are therefore of no use in deciding the exact age of the bed containing them. The only species on which any argument can be founded are *Belemnites attenuatus*, *B. minimus*, and *Ostrea acutirostris*.

The Belemnites are decidedly Gault forms, and do not, so far as we know, occur in true Chalk Marl, where Belemnites are not

common, though *B. ultimus* occurs sometimes; it is true that all three are often regarded as varieties of one species, but that makes no difference to the fact of the two varieties being specially characteristic of the Gault.

Ostrea acutirostris has not, I believe, previously been found below the Chalk Marl, but it is not a common shell anywhere, and is believed to occur in Upper as well as in Lower Chalk, so that it is evidently a species which has a long range.

The statement that *Ostrea vesicularis* has not been discovered below the Chalk is quite erroneous, for it is a common shell in the Upper Gault of Folkestone and elsewhere.

(3) Lastly, the clay above the "coprolite bed" at West Dereham has the lithological characters and general appearance of Gault. It is by no means unusual for the lower part of the Gault to contain fossils in the form of phosphate casts, more or less rolled and worn; such phosphatized fossils are particularly abundant within twenty feet of the base of the Gault in Buckinghamshire, and in the same county the passage-beds between the Gault and Lower Greensand often contain large lumps of sandy phosphate, which resemble those of the junction-bed at West Dereham. There is nothing therefore in the character or contents of the West Dereham clay that is incompatible with its being true Gault. For the reasons above stated we must maintain that all the previous authors were right in accepting the sections near West Dereham as proving the existence of Gault in that part of West Norfolk. How much farther north the Gault extends is another question which we are endeavouring to ascertain, and such evidence as we can obtain will be embodied in a paper which we intend to bring before the Geological Society. We shall also endeavour to account for the apparent passage between the Gault and the Chalk Marl; but we may remark that at Shouldham we found what appears to be the true glauconitic base of the latter, above the clay which Mr. Reid describes as containing *Belemnites* and *Plicatula*.

[*Postscript.*—Since the above was written we have had a boring made in the quarries at Stoke Ferry to a depth of fifty-five feet, and have proved the existence of a bed of Chloritic Marl at the base of the Chalk Marl, and resting on blue clay; the total thickness of the Chalk Marl there is seventy-three feet, and it must be remembered that below this there is at least sixty feet of Gault.]

VI.—Note on the Foliation of the Lizard Gabbro.

By Colonel C. A. McMahon, F.G.S.

THE appearance of Professor Bonney's letter in the December Number of the Geological Magazine, in which he suggests that Mr. J. J. Harris Teall's proposed explanation of the cause of the foliation of the Lizard gabbro "ought to be regarded as an hypothesis on its probation, and should not be quoted as an undoubted fact," emboldens me to offer some remarks on the subject.

Mr. Teall suggests that the "foliation in the Lizard gabbro is the

result of pressure" acting "after the consolidation of the rock;" or, as he puts it shortly in another place, the foliation is "a secondary structure due to earth-movements acting upon the *solid* rock." [The italics are mine.]

Mr. Teall does not expressly state, in his interesting and valuable paper, how the pressure acts so as to produce the results described; but we are told that at Pen Voose "massive gabbro passes over into gabbro schist at a fault plane," and "the foliation in the gabbro is such as would be produced by a shearing motion parallel with the fault plane."

Are we to understand that foliation has been produced by mere mechanical crushing, and consists of the rearrangement of minerals already formed sliding over each other's backs—a sort of mineralogical leap-frog—in consequence of a "shearing motion parallel with the fault plane;" or are we to understand that the "shearing motion" was transmuted into heat, and the heat so produced resulted in the fusion and subsequent recrystallization of the component minerals?

On either supposition I shall be glad to know how the foliation of the "veins and dykes of gabbro" to the north of Coverack, and the "small dykes of gabbro in the serpentine near Karakclews," is to be accounted for? Do all these veins and dykes concur with fault planes, or do they ramify in all directions in the usual manner of intrusive veins? If they coincide with fault veins, how is it that they are not always foliated? Mr. Teall states that the Coverack veins, and the small dykes near Karakclews, are "often foliated" (which implies that sometimes this is not the case); and further, that "not seldom one may see the transition from massive gabbro to gabbro schist taking place in the space of a few inches." If the veins and dykes in question coincide with fault planes, this occasional failure of "shearing motion" to produce foliation seems to need explanation. On the other hand, if some of the foliated veins and dykes do not coincide with fault planes, I fail to see how the "shearing" hypothesis can account for the foliation.

Again, if the foliation is accounted for on the supposition that the shearing motion developed heat, and recrystallization took place on the subsequent cooling of a rock in which molecular motion had been set up by the heat so developed, I do not at present understand how masses of gabbro "more than a hundred yards in width" (p. 487) have become, "with a few local exceptions, foliated throughout" their "entire mass." If the heat produced was sufficient to fuse the rock, why was its structure, on reconsolidation, not granitic, as it presumably was on its first consolidation, and as the dykes, sheets, and veins of ordinary eruptive rocks are?

Most geologists with field experience will doubtless be able to point to numerous instances of such eruptive dykes, and sheets, that have consolidated under enormous pressure, but which, notwithstanding, do not show a trace of foliation.

The above, I think, are difficulties which need clear explanation before the hypothesis can be accepted that pressure acting on a *solid* rock is sufficient to account for the foliation of the Lizard gabbro.

In the mean while, I venture to offer another explanation for consideration.

After having studied what used to be called the granitoid-gneiss of the Himalayas for some time, I came to the conclusion, from the stratigraphical, petrological, and microscopic facts observed, that what is now called the gneissose-granite of the Himalayas was erupted through lines of fracture in a *partially consolidated* condition.

I do not wish to apply that explanation to all cases, but I suggest a modification of it to account for the foliation of the Lizard gabbro; namely, that the latter was produced by "shearing motion" on the rock after its consolidation had advanced considerably but was still incomplete. This, it seems to me, would account for the observed facts better than any hypothesis yet proposed for acceptance; it would account for the foliation being generally marked at the contact of the gabbro with other rocks along joint planes; it would account for any signs of crushing in the gabbro that the microscope may reveal; and indeed for all the observed facts so far as I am acquainted with them. The great depth to which the foliation sometimes extends might, on this hypothesis, be accounted for either by supposing that the "shearing motion" continued for a long time; or, better still, that it was repeated frequently at intervals of sufficient duration to allow the marginal portions of the gabbro to cool and consolidate. Very slight movements parallel with the fault-plane would be sufficient, on the latter supposition, to produce foliation to a great depth.

If the foliated veins and small dykes, alluded to by Mr. Teall, do not run with fault planes, the foliation might be explained on the supposition that they were, like the gneissose-granite of the Himalayas, intruded in a viscid. or semi-plastic condition, when the shearing of the main mass of the gabbro along the fault planes was going on. Traction action on an imperfectly consolidated mass would in this case account for the foliation observed.

The fact that in some of the dykes a rapid passage from a foliated to a granitic structure is observed, is of course a difficulty in the way of any hypothesis; but I suggest that on my hypothesis it is capable of explanation. In the first place, I think it might reasonably be supposed that the cooling, and consequent consolidation, of the rock proceeded more rapidly in some parts of the dyke than in others. Rocks are rarely perfectly homogeneous; we often find variations in density, and hardness, within short distances even in some rocks of apparently homogeneous composition—a difference not due to weathering, but which weathering, and the agents of erosion, speedily find out. Then the power of conducting heat must have varied much in the bounding rocks. From these two causes the solidification of parts of a dyke might have been in advance of neighbouring portions, and have resisted the shearing motion more than the latter. The portions in which solidification was most advanced might thus have retained their granitic structure, whilst the less solid parts might have yielded to the shear and have become foliated.

In the second place, I think it possible that shearing motion might result in the development, or what would come to the same thing,

the retention of heat (owing to variations in the conducting power of the surrounding rocks), more in some spots than in others; and thus some parts of the dyke might become more fused than other portions, and might lose the foliated structure previously imparted by the shearing motion. The heat thus generated, or retained, would account for the assumption of a granitic structure in portions of a dyke, but not for the foliation of the other portions.

Mr. Teall considers "that the most convincing proof that the foliated structure is the result of movement after the consolidation of the rock is furnished by its relation to fault planes. A rock must necessarily be solid before it can be faulted." But we learn from Mr. Teall's paper that there must have been a lengthened series of earth-movements at the Lizard; thus he speaks of the "superposition of the effects of distinct movements"; the fractures therefore, to which he alludes, may have taken place after the consolidation of the rock; and after the foliation had been produced. Do all the faults in the gabbro present foliated margins? I gather from Mr. Teall's article (read with Professor Bonney's paper in Q.J.G.S. vol. xxxiii.) that this phenomenon is principally to be observed at the junction of the gabbro with other rocks. But even if some of the faults *in* the gabbro do present this phenomenon, I do not see why, in those exceptional cases, the faulting should not have taken place before the *complete* consolidation of the gabbro. If the fault ran through the rocks above and below the gabbro, the gabbro would surely have divided in the line of the fault as readily as a layer of jam between slices of sponge cake does when the cake is broken. If the gabbro was not completely rigid where thus divided, the shear might have produced a foliated structure in the portions exposed to the tearing effects of the rupture.

In conclusion, I would invite the attention of the readers of the Geological Magazine to the sketches of two foliated gabbro veins in the Lizard serpentine drawn by Professor Bonney (figs. 2 and 4), which will be found at pp. 893, 897, of his paper in vol. xxxiii. (1877), Q.J.G.S. Professor Bonney, in his letter published in the December Number of your Magazine, tells us that the serpentine is "free from all indications of mechanical disturbance." This being so, it seems physically impossible that the foliation of the gabbro in the veins depicted in his paper can be due to "shearing movements" acting on a "solid rock." Furthermore, it will be observed that the foliation in one of the veins (fig. 2) not only runs with the two sides of the vein, but also with the boundary of the terminal end (*vide* the illustration). Professor Bonney tells us that the foliation runs "roughly parallel to the longer sides of the vein, except towards the top, where it tends to become parallel to the upper surface." This is what I should expect to see if gabbro in an imperfectly consolidated, or semi-plastic condition were forced into, or through, an opening in the serpentine rock; but it is, to me, totally incomprehensible on the hypothesis of "shearing motion parallel with a fault plane."

NOTICES OF MEMOIRS.

I.—Preliminary Note on the Ordovician Rocks of Shropshire. By Professor C. Lapworth, LL.D., F.G.S.

[A Paper read before the British Association, Birmingham, Section (C) Geology, September, 1886.]

In this note the author gave a brief review of the history of discovery and opinion respecting the Lower Palæozoic rocks of Wales and the West of England, and pointed out that the results developed of late years by British and foreign geologists made it evident that Murchison's Silurian System, as defined in the later editions of "Siluria," was in reality composed of three distinct geological systems, and that of these three the only one which belonged to him by right of discovery and correct description was the so-called Upper Silurian, which was therefore the only true *Silurian System*. The lowest known fossiliferous system (the Primordial Silurian of Barrande) was not discovered by Murchison, but by Sedgwick, who regarded it as the lower half of his own *Cambrian System*, and it ought, as a matter of justice and convenience, to retain that name only. The intermediate system (claimed as Lower Silurian by Murchison, and as Upper Cambrian by Sedgwick) belonged to neither, for its life-types are wholly distinct from those of the true Cambrian below and of the true Silurian above. This distinction must be recognized by a distinct title. The Silurian was named by Murchison after the ancient British tribe of the *Silures*, who inhabited South Wales, where its rocks attain their fullest development. The rocks of the disputed intermediate system, however, are most fully developed in North Wales—the land of the equally ancient tribe of the *Ordovices*. The author had proposed in 1879 that the middle system should be entitled the *Ordovician System*, after this old tribe, and this name is gradually coming into use among geologists.

During the last few years the sequence and fossils of the Ordovician strata of Shropshire have been studied in detail by the author, and their igneous rocks, both interbedded and intrusive, have been worked out by Mr. W. Watts. In this note a general summary of his own conclusions was communicated by the author, and illustrated by maps, sections and lists of characteristic fossils.

Ordovician strata occur in two distinct sub-areas in Shropshire, viz. in the district of Shelve and Corndon to the west of the Longmynd, and in the Caradoc district to the east of that range. In both districts these strata are overlain unconformably by the basement beds of the Silurian, *which rest transgressively upon every zone of the Ordovician in turn.*

In the Shelve and Corndon district the Ordovician rocks repose at once upon the highest known strata of the local Cambrian, and are arranged in the following ascending order:—

Shelve Series.

(*a*) *Stiper Group*, consisting of the well-known Stiper Quartzites and their associated strata.

(*b*) *Ladywell Group*, composed of the dark shales and flagstones of Mytton, Ladywell and Hyssington, with *Dichograptidæ* and *Ogygia Selwynii*, etc.

(*c*) *Stapeley Volcanic Group*, andesitic lavas, ashes and interbedded shales.

Meadowtown Series.

(*a*) *Weston Group of Grits*, flagstones and dark shales.

(*b*) *Middleton Group*, composed of dark shales, with *Didy. Murchisoni*, and calcareous flagstones, with *Ogygia Bucchi* and *Asaphus tyrannus*.

(*c*) *Rorrington Group*, of intensely black shales, with *Cœnograptus gracilis* and *Leptograptus*.

Chirbury Series.

(*a*) *Aldress Group*, composed of the *Spy Wood* calcareous *grit*, and the *Aldress* Graptolitic shale.

(*b*) *Marrington Group*, including the *Hagley* volcanic ashes and shales, and the *Whittery* ashes and overlying shales.

The only Ordovician rocks occurring east of the Longmynd are those forming the local *Caradoc Series* of the author (the Caradoc formation of geologists). The basement beds of this series rest *unconformably* upon all the older rocks of the district—upon the so-called Uriconian, Longmyndian, Wrekin Quartzite, and Shineton Shales, and its component zones are each covered up unconformably in turn by the basement beds of the Silurian. This isolated Ordovician Series is composed of the following members:—

Caradoc Series.

(*a*) *Hoar Edge* Conglomerate, grits and limestone; (*b*) *Harnage Shales*; (*c*) *Chatwall Sandstone*; (*d*) *Longville Flags*; and (*e*) *Onny*, or *Trinucleus Shales*.

The Shelve series answers generally to the strata commonly designated *Arenig*; the Meadowtown series includes the typical members of Murchison's *Llandeilo*; and the Chirbury and Caradoc series correspond broadly to Sedgwick's *Bala* formation of North Wales.

Some of the most characteristic fossils of each of the Ordovician sub-formations and zones were given, and it was shown how naturally the physical and palæontological sequence agrees with that of the corresponding Ordovician rocks of Britain and Europe. The peculiar physical conditions of the Shropshire area in Ordovician times, as indicated by the very different lithological characters of the strata upon the opposite sides of the Longmynd, was pointed out; and the evidences for the geological horizons and relationships of the volcanic rocks indicated in outline. In conclusion, it was pointed out that the clearness and simplicity of the sequence, and

the highly fossiliferous nature of its strata, render it tolerably certai that this Shropshire succession will form the general standar to which all other British Ordovician strata must ultimately b referred.

II.—Transactions of the Cumberland and Westmorland Asso ciation. No. XI. 1885-86.

THIS part contains notes on "The Mineral Springs near Keswick," by J. Postlethwaite (pp. 142–145.) They comprise saline water at Brandley Mine and Saltwell Park, and a chalybeate spring at Wood end Mine, near Threlkeld. Mr. T. V. Holmes contributes some remarks on "Purple-grey Carboniferous Rocks and the Whitehaven Sandstone" (pp. 146–148). He points out that purple-grey rocks similar to the Whitehaven Sandstone, occur on almost every horizon throughout the Carboniferous series in Cumberland.

REVIEWS.

I.—M. Dollo's Notes on the Dinosaurian Fauna of Bernissart.

THE remarkable preservation of a Fauna of Wealden reptiles a Bernissart has been utilized with admirable skill, so that th skeletons, though necessarily extracted in fragments, have bee again reunited in the anatomical relations of the bones, in th Brussels Museum, under the able direction of M. de Pauw.

The animals thus displayed in a perfection which no other reptil fauna in Europe can surpass have been the subject of a series o valuable preliminary memoirs by M. Dollo, published during th last few years in the Bulletin du Musée Royal d'Histoire Naturell de Belgique. The object in issuing these notes, in anticipation o the full description which is to follow, is professedly to gain fron the criticism of scientific men suggestions which may aid in th perfection of the final monographs. I gladly avail myself of thi opportunity for drawing attention to the excellent work whic M. Dollo has thus far performed; and at the same time offer a fe suggestions upon points where a difference of opinion seems to m legitimate.

The great interest of this work centres in the Dinosaurians, whic were examined by M. Boulanger, and referred to the *Iguanodo Mantelli*, and a new species named by him *Iguanodon Bernissartensis* in days before M. Dollo commenced his labours.

The author begins by contrasting the differences between thes two forms. Separating the characters of the animals, we are able t define the two types thus: *Iguanodon Mantelli* is a relatively smal and slender animal, with a skeleton nearly twenty feet long. It skull, 50cm. long, is relatively elongated, being moderately deep and three times as long as wide. The anterior nares are lon narrow vacuities, half as long as the lower jaw, and descendin anteriorly for some distance over it. The orbit for the eye is rathe longer than deep. The temporal vacuities, seen from above, ar

long narrow slits, which diverge anteriorly. The scapula is relatively slender and elongated, being eight times as long as wide. The coracoid is pierced by a foramen placed near to the scapular suture. The posterior border of the coracoid is rounded—the sternal elements are relatively small. The fore limb is half the length of the hind limb. The humerus is relatively short. The manus is nearly one-fourth of the length of the limb. The ungual phalange of the first digit, which forms a sort of spur, is one-third the length of the longest digit. The metacarpal bones are compressed together laterally, indicating a relatively narrow extremity. There are five sacral vertebræ. The pre-acetabular process of the ilium is nearly one-half the length of that bone. The pre-pubis is short, thin, and expanded; its length, depth and thickness being expressed, in millimetres, by the numbers 400, 200, 10. The large lateral trochanter of the femur is in the middle of the length of the bone. The tibia is relatively long.

On every one of these points of structure the animal named *Iguanodon Bernissartensis* differs, so that the animal may be defined in comparison with *I. Mantelli* as being more massive in all its proportions; and it is about thirty-three feet long. The skull is relatively broad, the width being half its length, which measures 65cm. The anterior nares do not descend so low upon the lower jaw, while the length of the anterior narine is contained three times in the length of the lower jaw. The orbital vacuity is elongated vertically. The temporal fossa are each wide and four-sided in form. The scapula is relatively stouter and shorter, being six times as long as wide. The coracoid is pierced by a foramen, which takes the form of a notch, opening posteriorly towards the humerus. The sides of the bones are excavated, and their posterior borders diverge, as if to receive sternal elements. The large sternal bones are relatively strong. The fore-limb is two-thirds as long as the hind limb, so that the proportions of the extremities are more nearly equalized. The humerus is relatively longer, and the manus shorter, being scarcely one-fifth the length of the limb. The first digit has its spur-like, inwardly directed, terminal phalange, half as long as the longest digit. The metacarpal bones are sub-quadrate in transverse section. There are six vertebræ in the sacrum. In the pelvis, the pre-acetabular part of the ilium is only one-third of its total length. The pre-pubis is long, massive, and straight. Its length, depth and thickness being expressed in millimetres by the numbers 700, 170, 40. The large lateral trochanter on the femur is situate in the lower third of the bone. The tibia is relatively shorter.

The author then goes on to discuss the taxonomic value of these differences, considering three hypotheses. First, whether the two varieties are to be attributed to age; secondly, whether the differences may be individual or sexual; and, thirdly, whether they afford evidence of two species, or indicate two genera. M. Dollo concludes that the differences enumerated constitute a species. This conclusion is based on a consideration of the characters by means of

which various authors have defined the genera which are allied to *Iguanodon*; and on an estimate of the characters by which the three known species, at present referred to *Iguanodon*, have been characterized. Those species cannot, however, be completely compared. The *Iguanodon Mantelli* has five sacral vertebræ, and the pre-acetabular part of its ilium is half the length of the bone. *Iguanodon Prestwichi* has four sacral vertebræ. *Iguanodon Seelyi* has the ilium three times as long as its pre-acetabular portion; but its sacrum is not at present known.

The author then goes on to show that the differences of proportion between the principal bones of the fore and hind limbs in the type specimen of *Iguanodon Mantelli*, and the smaller *Iguanodon* in Brussels, amount to only a small percentage; and compares the type slab from the Lower Greensand of Maidstone with the Brussels animal, with the following results:—

	Ilium.	Femur.	Tibia.	Scapula.	Humerus.	Radius.
Maidstone spm....	0·75	0·81	0·75	0·72	0·47	0·45
Brussels spm. ...	0·71	0·71	0·67	0·62	0·43	0·37

showing that the Brussels animal is somewhat smaller, and that the proportions of the fore and hind limb are not quite the same. He then discusses the nomenclature of the larger type, and recognizes its extremely close correspondence with the *Iguanodon Seelyi* of Hulke, with which he would have had apparently no hesitation in identifying it, but for the following remarkable passage, in which Mr. Hulke states "I had long possessed evidence that *Iguanodon* had a scuted hide; but until the acquisition of these remains, such evidence was very fragmentary. In cutting away the rock from the larger bones of the hind limb, I found beneath it a layer of bony tissue, separated from the endoskeleton by a deeper layer of rock, enclosing much black carbonaceous matter. From its position with reference to the endoskeleton, it was obvious that the outer layer of bony tissue was exoskeletal—was in short a dermal mail." Mr. Hulke further describes these bones as irregularly polygonal, with a surface slightly pitted, some of them 2cm. thick and 7cm. in diameter. M. Dollo finds evidence of the integument, but no trace of bony armour, which he thinks should separate the species, but maintains that if the large Brussels form is identical with the *Iguanodon Seelyi*, priority must be claimed for Boulanger's name, *Iguanodon Bernissartensis*.

The author follows Marsh in placing *Iguanodon* in the Ornithopoda, but makes a criticism, which was valuable at the time, in opposition to the view that clavicles formed a characteristic of the group, urging that the bones which were thus identified by Marsh are elements in the sternum. The note concludes with a definition of the order Ornithopoda, and its families, a definition of *Iguanodon*, and definitions of the three species.

There is no doubt that M. Dollo is substantially in harmony with Mr. Hulke in his views concerning the classification of these Dinosaurs. But I ventured, when the description of the *Iguanodon Prestwichi* was read before the Geological Society in 1880 to express an opinion that the characters of the sacrum, of the

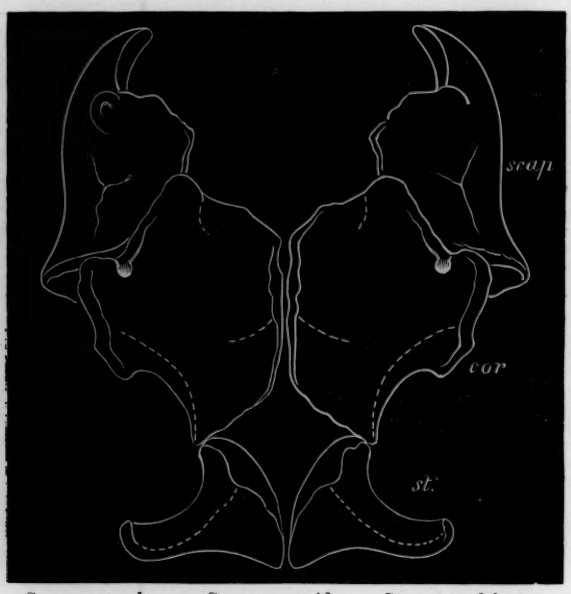
astragalus, and os calcis, the relation of the fibula to the tibia and other osseous characters, could only be regarded as generic characteristics. More mature consideration has only deepened my conviction that the *Iguanodon Prestwichi* is not an *Iguanodon* in the sense in which the term *Iguanodon* should be used as a generic distinction. There would be an end of zoological method if organic differences of the magnitude which divide this animal from the *Iguanodon Mantelli* could be classed as specific characters. The earlier writers made species in this way; but it was by the institution of a method altogether distinct from that used in the modern study of existing life. I believe it to be imperative that no such difference of method should prevail in the study of existing and extinct animals, and therefore contend that, since the structures which I have named differentiate the Kimmeridge Clay animal so that it would have been referred to a new genus had it been an existing animal, we have no choice but to class it as a genus, though no name has as yet been proposed to designate its characteristics. Similarly, when the Memoir on *Iguanodon Seelyi* was read before the Geological Society, two years later, I suggested that it would have been safe to have constituted it also as a new Dinosaurian genus. I therefore find myself differing from M. Dollo, not so much upon the results of his own work, as upon matters in which he depends upon and has the support of one of our most accomplished and most cautious comparative anatomists. But when the value of the characteristics of these two *Iguanodon* types, which M. Dollo has so well contrasted, is estimated, I am tempted to ask, is there any living reptilian genus which in the skeletons of its species comprises so wide and varied an assemblage of differential characters? If the differences were limited to one series of characteristics, or to one region of the body, we might accept them as specific; but when they range through all parts of the skeleton, so as to imply many differences in the soft parts of the body, I cannot but reiterate that the close correspondence between *Iguanodon Bernissartensis* and *I. Seelyi* sustains my earlier belief that the larger Belgian type constitutes a new genus. The form of the head, of the nares, of the orbit, of the temporal vacuities, of the pre-dentary bone, in *Iguanodon Mantelli*, all seem to me generic characters; and the elevation of the nasal bones into a sharp crest may be of similar importance, seeing its relation to the nasal crest or horn in *Ceratosaurus*. These characters are sustained by the proportions of the several parts of the ilium, the form of the prepubic bone, the shape of the femur and position of its third trochanter, no less than by the characters of the scapular arch and the metacarpal bones. The taxonomic value of these characters should be beyond question.

If I am right in my exposition that two of the three species which have hitherto been referred to *Iguanodon* belong to new genera, then it necessarily follows that I am unable to accept either the data with which M. Dollo works, or the conclusions at which he arrives in consequence, in so far as this concerns the classification. It is unnecessary to define my view by suggesting names for these

genera now. Some bones of the *Iguanodon Seelyi* type may have been referred to *Pelorosaurus* in Mantell's collection, but the genus *Pelorosaurus* has no existence, and should be erased from catalogues as having been founded upon a humerus of *Cetiosaurus*.

In his second note M. Dollo limits himself to a discussion of the sternum. He describes the pair of large triangular bones with elongated processes which were found in association with the scapular arch, bones of the fore limb, and sternal ribs, and believes himself justified in concluding that they are in their natural undisturbed position in contact with the coracoids, and therefore combats the conclusion of Professor Marsh that they are the clavicles. In the remainder of the paper the author goes on to cite the descriptions of the sternal bones in other Dinosaurs, which have been given by other writers.

I give in outline the sternal apparatus as restored by M. Dollo.



Scap.—scapula. Cor.—coracoid. St.—sternal bones.

But I am unable to accept his arrangement of the bones. Fully admitting that the bones which he terms sternal are in natural contact with each other in his slab (pl. xii. fig. 2), I am unable to admit that they are in natural contact with the coracoids. Mr. Hulke has been more fortunate in obtaining a better preserved example of the sternal apparatus of *Iguanodon Mantelli* (figured in the Quart. Journ. Geol. Soc. August, 1885), and he regards the bones cited by Dollo as a pair of sternal ossifications, comparable to the immature sternum of a Struthious bird, as being clavicles—a conclusion previously arrived at by Mr. William Davies, and adopted by Professor Marsh. I first studied the specimen described by Mr.

Hulke in 1870, and failed to form any decisive opinion on its interpretation, till I saw it again after Mr. Hulke's paper had been read. Mr. Hulke regarded the fossil, which he described, as consisting of the clavicle and interclavicle of *Iguanodon*. And, in a restoration, the clavicles are shown divided from each other by the interclavicle, which has its chief extension posterior to them. The clavicles are represented as also articulating with the scapula; while the coracoids, represented as passing behind the clavicles and anterior part of the interclavicles, articulate for a short distance with the sides of the interclavicles, and afterwards with a hypothetical sternum, which is supposed to pass behind the interclavicle. I regret to find myself unable to adopt any one of these determinations. First, what Mr. Hulke regards as sutures defining the specimen into clavicles and interclavicles, I regard as fractures in the specimen. The bones, which for the moment I will distinguish as the sternal elements of Dollo, I regard as being in close median contact, as in the Belgian specimen already cited. I am unable to admit that these bones articulated with the scapula, because I have never seen a facet on any *Iguanodon* scapula, which could have received such a bone. While the surfaces on Mr. Hulke's fossil sternum, which are supposed to have articulated laterally with the coracoids, seem to me to have given attachment to sternal ribs. It is manifest from evidence in the British Museum that the specimen found by Mr. Beckles, and figured by Mr. Hulke, and represented in the British Museum by an excellent cast, includes another ossification, extending beyond the sternal bones of Dollo. Professor Cope has some interesting observations on this subject in the American Naturalist for February, 1886. First he suggests that the bones in dispute are neither clavicles nor sternum in the ordinary sense of the term, but the pleurosteal elements in the sternum, which were developed so that the long process extended backward and outward, as in the sternum of a fowl. It happens that *Diclonius mirabilis* has these elements perfectly preserved, and closely resembling in form and arrangement the same bones in *Iguanodon Mantelli*. Professor Cope, however, identifies his sternum with the sternum of *Monoclonius crassus*, so that he would place the coracoid bones in direct articulation with these sternal bones, almost in the position in which Dollo placed them originally. Professor Cope was unaware of the true structure of the sternal apparatus, described by Mr. Hulke, or he would not have proposed to bring the coracoids into connection with osseous surfaces, which in that fossil are manifestly separated by a broad, thin, ossified mass, from any other bone. Nevertheless, I entirely agree with Professor Cope that the bones in dispute are not clavicles, and further, that the specimen to be understood must be turned upside down, in the way which he suggests. I am also prepared to accept these sternal elements as approaching more nearly to the pleurosteal elements in the sternum of a bird than to any other ossification, in so far as they are posterior to the articulations for the sternal ribs; but in position they are essentially the xiphoid bones, which have preserved as marked and as distinctive an

individuality in the sternum of Dinosaurs, as in the plastron in Chelonians. The sternal ossification, anterior to these xiphoid elements, which is seen in the fossil figured by Mr. Hulke, is thin, and is not commonly preserved. The anterior extremity of this Dinosaurian structure is at present unknown. The posterior xiphoid ossification may have been connected with the prepubic bones, in much the same way as the abdominal ribs of Crocodiles extend down to the pubic bones.

In the third paper M. Dollo discusses the attitude of the *Iguanodon*. First, there is the view originated by E. D. Cope that they progressed chiefly upon their posterior limbs, in the manner of the Ratitæ, of which they were supposed to be the parent stock. Secondly, I have accepted the bipedal progression, but denied that these Dinosaurs are the ancestors of Birds. And, thirdly, Sir R. Owen regards them as having been exclusively aquatic, with the body carried in a horizontal position. In support of the upright position, it is urged that there is a remarkable correspondence between the pelvis of *Iguanodon* and that of Ratite Birds; while the difference in structure between the fore and hind limbs of *Iguanodon*; the relative dimensions of the head and thorax as compared with quadruped reptiles; the nature of the vertebral column; and the Wealden footprints described by Beckles and other writers furnish conclusive evidence. Each of these points is considered in detail.

The author begins by discussing the pelvis, and endeavours to combat the views of Sir R. Owen, and to prove that the ilium of *Iguanodon* agrees in the most striking manner with the homologous element in Birds. I am not concerned to do more than urge that the author rather undervalues the resemblances to the ilium of a Crocodile. If we begin with the geological history of the Dinosaurian ilium, and trace it in development through successive generic types of evolution, I do not see how the conclusion can be resisted that the Dinosaurian ilium is a modification of the Crocodilian ilium, which only resembles the ilium of a bird in such ways as indicate a modification of the Crocodilian plan. This plan of the Dinosaurian ilium, as seen in such types as *Zanclodon* and *Thecodontosaurus*, is remarkable for the mass of the bone lying behind the acetabulum, as in Crocodiles. The form of the post-acetabular part is wonderfully alike in both groups. And the difference begins with the Dinosaurian elongation of the pedicle for the pubis, which throws the bone upward, and the concurrent elongation of the preacetabular process, which at first is so short as not to extend in advance of the acetabulum. Even when the latter process is elongated, as in *Iguanodon Mantelli*, or *I. Bernissartensis*, it never loses trace of its origin, or approximates to the ilium of a bird in form, any more than in osteological connections; though the ilium of *Stegosaurus* makes perhaps as near an approximation to the Ratite contour as is seen in a Dinosaur. The ischium and pubis of *Iguanodon* are treated by M. Dollo in the same spirit, with the conclusion that the ischium in Dinosaurs, and especially in *Iguanodon*, shows a strong avian resemblance, while in the pubis there is

perfect agreement. This conclusion is open to exactly the same criticism as we offered concerning the ilium. If the only Dinosaurs known were such types as *Morosaurus*, *Atlantosaurus*, *Brontosaurus*, and the allied types described by Professor Marsh, no doubt could exist that the Dinosaurian pelvis was not avian. Nor would its avian resemblances have been sustained by the discovery of such types of animal as have been named *Ceratosaurus*, *Allosaurus*, and *Cœlurus*. Yet it is perfectly true that if *Iguanodon*, *Camptonotus*, and *Laosaurus*, were the only known Dinosaurs, an avian resemblance might be recognized in the ischiac and pubic bones. But the very fact that these bones vary their forms and change their resemblances within the same order, so as to be avian in some genera, and not avian in others, robs the resemblance of all taxonomic importance, and demonstrates that the character of an order or sub-class cannot at the same time be both avian and not avian. The resemblances accordingly sink to the value of sub-ordinal characters, by which some Dinosaurs may be differentiated from others, and are thus proved, I think, to owe their remarkable avian forms to conditions of existence. Exception is taken by M. Dollo to certain details in Mr. Hulke's restoration of the pelvis of *Iguanodon*, stating that in *Iguanodon Mantelli* the pubis is not inclined ventrally inward and forward, but, on the contrary, ventrally forward and outward, like the rudiment which exists in birds. There is no symphysis pubis. The post-pubis is not continued to the extremity of the ischium, and is therefore not applied against it in the distal region. M. Dollo also takes exception that the Brussels specimens show by the way in which processes from the ischium extend in front of the pubis, two foramina, instead of the one shown in Mr. Hulke's restoration. M. Dollo is certainly correct with regard to the structure in the genus represented by *I. Bernissartensis*; but he has presented no evidence that Mr. Hulke was incorrect in his restoration of the pelvis of *Iguanodon*. He objects to the identification of the pre-pubis of *Iguanodon* with the small process which is similarly placed in birds, by showing that the supposed pre-pubic structure is developed from the ilium in the common fowl, and cannot therefore be homologous with the pre-pubis of *Iguanodon* and other Dinosaurs. The author enters into many details to contest the views which have been advanced by Sir Richard Owen concerning the interpretation of the pelvis of Dinosaurs, and does good service in bringing under the notice of continental writers the more modern interpretations which, we may say, without any disparagement to M. Dollo's originality, have long been current in this country.

H. G. Seeley.

(To be continued.)

II.—United States Geological Survey: Bulletin No. 28. The Gabbros and associated Hornblende Rocks occurring in the Neighbourhood of Baltimore, Md. By G. H. Williams. Pp. 59 and iv. Plates. (Washington, 1886.)

THIS is a valuable contribution to American petrology, and many of the conclusions established must have a special interest for

British geologists also. The author has minutely studied, in the field and by microscopical and chemical analysis, the conversion of a pyroxenic to a hornblendic rock. The rocks occur (Chapter I.) in an oval district 50 square miles in area, breaking through the gneissic rocks to the west and north-west of Baltimore. The pyroxenic type (*Hypersthene-gabbro*, Ch. II.) is a massive rock consisting essentially of bytownite, diallage, hypersthene, and some brown hornblende. The typical hornblendic rock (Ch. III.), which the author names *Gabbro-diorite*, is either massive or schistose. It contains green hornblende, often true uralite but in part compact, and bytownite showing incipient saussuritization and also breaking up into epidote near the contact of the felspar with adjacent hornblende.

Chapter IV. deals with the genetic relations of these two very different rocks. In the field they are found to be inextricably involved, and to graduate imperceptibly into one another. The average analyses of the two agree closely, though considerable variations of composition occur under each type. Microscopical examination of the transition-zone reveals the nature of the changes that have taken place. Both the diallage and the hypersthene of the gabbro are seen to pass gradually into green hornblende, but in different ways. The conversion of the diallage is apparently a true paramorphosis, this mineral and the resulting hornblende giving closely similar analyses. The hypersthene, on the other hand, for its amphibolization, must take up alumina and lime from the felspar, and in the earlier stages of the change the mineral is bordered at its contact with the felspar by a double rim, the inner zone of fine colourless fibres, the outer dark green and comparatively compact. This is analogous to what has been observed when olivine passes into amphibole.

The evidence of the metamorphism of gabbro into diorite in this district is complete at all points. The author regards augite and hornblende as dimorphous, the former representing the stable form of the molecules at high, the latter at low temperatures. Augite being unstable at low temperatures will tend to revert to hornblende under any influence which facilitates molecular motion. Pressure, though a potent condition in many instances, is not regarded as necessary. The concluding chapter is devoted to the description of certain associated olivine-bearing rocks and serpentines. The chief type of olivine rock is described as a felspathic peridotite: besides olivine, bronzite and diallage, it contains up to five per cent. of bytownite, partly zeolitized. The olivine and pyroxenic constituents exhibit the usual secondary actions, and the double rim of amphibole is also found at the contact of the olivine and felspar. The structure is remarkable, the olivine being the latest-formed mineral, in which the pyroxenes occur porphyritically. The most abundant type of serpentine in the district is one containing tremolite, probably secondary after pyroxene. In some cases a further change of amphibole into talc is observed. A. H.

III.—Terrains Paléozoiques du Portugal. Etude sur les Bilobites et autres Fossiles des Quartzites de la base du Système Silurique du Portugal. Par J. F. N. Delgado, Chef de la section des travaux Géologiques. 4to. pp. 113, with 43 phototype plates. (Lisbonne, 1886.)

IN central and northern Portugal the problematical bodies known as *Bilobites* or *Cruziana* are the most ancient fossils known; they occur in great abundance in beds of grit and quartzite, at an horizon probably corresponding to the Arenig grits of this country, and to the "grès armoricain" of Normandy and Bretagne. M. Delgado, in this elaborate memoir, discusses in detail their characters and probable origin, and gives full descriptions of the varieties of form which they present. A striking feature of the work is the magnificent series of plates, in which the fossils have been phototyped, for the most part natural size, and they represent very clearly and faithfully their peculiar features.

M. Delgado maintains the same views respecting these bodies as MM. de Saporta and Marion, and upholds, with much skill, the opinion that they are the impressions of algæ. It cannot be said, however, that these Portuguese examples afford any fresh evidence, sufficiently decisive to decide the question as to their origin, and whilst giving due weight to the arguments so skilfully brought forward by the author, we do not think they are sufficient to counterbalance those which[1] Dr. Nathorst has lately re-stated, viz. that the impressions have been produced by the infilled tracks and burrowings of marine animals. G. J. H.

REPORTS AND PROCEEDINGS.

I.—December 15, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "Notes on *Nummulites elegans*, Sow., and other English Nummulites." By Prof. T. Rupert Jones, F.R.S., F.G.S.

The author finds in the "Sowerby Collection," now in the British Museum, the original specimens on which Sowerby founded his *Nummularia elegans* (1826, Min. Conch. vol. vi. p. 76). These are partly specimens from that part of the bed "No. 29" of Prof. Prestwich's section of Alum Bay[2] (Quart. Journ. Geol. Soc. vol. ii. (1846) p. 257, pl. ix. fig. 1), which is known to be the lowest of the Barton series; and partly some in a stone said to be from Emsworth, in Hampshire. The former are the same as those named *Nummulites planulata*, var. *Prestwichiana*, by Rupert Jones in 1852; and the latter are *N. planulata*, Lamarck (1804), and probably foreign. Thus *N. elegans* has priority over *Prestwichiana*; and as this last was determined by De la Harpe to be a variety of *N. wemmelensis*, Van den Broeck and De la Harpe, this variety should be var. *elegans*. The author thinks that, on broad zoological principles, *N. planulata* might still be regarded as the species; but, in view of the careful differentiation worked out by De la Harpe, he accepts the "specific"

[1] Geol. Mag. 1886, p. 409. [2] See Mr. H. Keeping's Article, *ante*, p. 70.

standing of "*wemmelensis*" as useful among *Nummulites*; but "*Prest wichiana*" has to give way to "*elegans*" for the peculiar "Barton" variety. A bibliographical history of the long-misunderstood *N. elegans*, Sowerby, description of this form and of *N. variolaria* (Lam.), notes on *N. lævigata* (Brug.), and an account of their range in England, complete the paper.

2. "On the Dentition and Affinities of the Selachian Genus *Ptychodus*, Agassiz." By A. Smith Woodward, Esq., F.G.S.

The genus *Ptychodus*, owing to the detached condition in which the teeth are usually found, has hitherto been imperfectly understood. Agassiz referred it to the Cestraciontidæ on account of a supposed resemblance in the arrangement of the teeth, and Owen's researches on their microscopic structure served to confirm this view. On the other hand, several writers have pointed out characters tending to show affinity between *Ptychodus* and *Rhynchobatus*.

More recently, however, Prof. Cope and the author had shown that the supposed affinities between *Ptychodus* and the Cestraciontidæ were only apparent, and in the present paper additional evidence was brought forward.

The author proceeded to describe several specimens of *P. decurrens* in the British Museum, and in the collection of Mr. H. Willett of Brighton, one of the latter, especially, containing, what had been previously entirely unknown, the dentition in part of both jaws. These specimens showed that each jaw contained six or seven longitudinal rows of teeth on each side of the median row, and that the genus must be referred to the true Rays, and not to the Cestraciont Sharks, though the precise family to which *Ptychodus* belongs was more difficult to determine. On the whole, the writer was disposed to assign it a place either amongst the Myliobatidæ or in their neighbourhood. The microscopic structure of the teeth was shown to be insufficient, by itself, to show their affinities.

3. "On a Molar of a Pliocene type of *Equus* from Nubia." By R. Lydekker, Esq., B.A., F.G.S.

A small collection of Mammalian remains from near Wadi Halfa had recently been placed in the author's hands; some of the bones were mineralized similarly to those of the Upper Pliocence of the Val d'Arno, or the Lower Pleistocene of the Narbadda valley. Amongst others the most interesting is a right upper cheek-tooth of *Equus* but little worn. It evidently does not belong to any of the late Pleistocene or Recent species of the genus, but to the more generalized group comprising *E. sivalensis*, etc.: though, bearing in mind the impossibility of distinguishing many of the existing species of the genus by their teeth alone, its absolute specific identity is not asserted. We may infer, then, that the ossiferous beds of Wadi Halfa are not improbably of Pliocene age, since this group of Horses, both in Europe, Algeria, and India, had totally disappeared after the period of the Forest-bed. Moreover, it is of interest, in view of previously expressed opinion, to find in the Tertiary of Nubia a species of this primitive group of *Equus* which is apparently more nearly allied to the Siwalik than to the European species.

II.—Jan. 12, 1887.—Prof. Judd, F.R.S., President, in the Chair.

The PRESIDENT announced the sad loss which the Society had sustained since the last Meeting, by the death on 4th January of Mr. John Arthur Phillips, F.R.S., who had been for several years a valuable member of the Council, and one of the Vice-Presidents of the Society.

1. "The Ardtun Leaf-beds." By J. Starkie Gardner, Esq., F.G.S., F.L.S.; with Notes by Grenville A. J. Cole, Esq., F.G.S.

The description of these beds by the Duke of Argyll thirty-five years ago indicated that enormous tracts of Trap in the Inner Hebrides were of Tertiary age. Prof. Edward Forbes, who described the leaves, inclined to the idea that they might be Miocene; but in estimating the value of this conjecture, we must remember that at the time the existence of Dicotyledonous leaves of similar aspect, but of undoubtedly Cretaceous age, was quite unsuspected, and that no typical Eocene flora had then been properly investigated or described. Prof. Heer, however, adopted the opinion that the age of this formation was Miocene, and unfortunately extended its application to formations containing similar floras in Greenland and elsewhere. One object of the present communication is to show that, instead of belonging to the Miocene, these floras are of Eocene age, and in fact older than the Thanet beds. The other object is to redescribe the plant-beds, and to show that they are part of a rather extensive series of sedimentary rocks intercalated among the Traps.

The rapid accumulation of knowledge as to the distinguishing characteristics of Cretaceous, Eocene, and Miocene floras has rendered the attainment of the former object at least possible, and it is of the greater importance, since the error in determining the age of the fossil floras of Ardtun and Antrim, and of a part of the Arctic flora, is a great impediment to further progress. Instead of all these immense thicknesses of beds belonging to the Miocene, they have their base somewhere in the so-called Cretaceous series; 400 feet higher up we are about the horizon of the Thanet Beds; while at 1000 feet up the flows were contemporaneous with the Bracklesham and Barton deposits. The first acid eruptions were Miocene, as shown by the floras preserved in Iceland.

The author described the various exposures from his own observations and Mr. Cole's notes. At Ardtun the Traps are surmised to be parts of once continuous flows, still represented at Staffa and Burgh, but broken through by an intrusive sheet. The leaf-beds are varied in composition, the richest being very friable, while the best matrix is a limestone as fine as lithographic stone, in which plant-remains are few, but exquisitely preserved. They are overlain by thick deposits of river-gravel, chiefly composed of flint or silicified chalk, but in which Mr. Cole has detected fragments of sanidine like that of Ischia or the Rhine, and of trachyte. At Carsaig the gravels are coarser and less evenly bedded, and the sandy matrix apparently is entirely made up of flint. The coarse gravels are flanked by sands and indicate a rapid flow of water, occupying a

valley not less than a mile across. The Ardtun gravels indicat a less rapid but more extensive river. The section at Burgh is ver like that at Ardtun, with the addition of an extensive ash-bed at th base, with sand instead of gravel, and with many hundred feet Trap above. In the Wilderness there is a small outcrop of Chall rubble, less than 300 square feet in extent, and evidently redeposite Some distance under this is Greensand *in situ*, then Lower Lias, an lastly Poikilitic sands. This descriptive part of the paper conclude with some remarks on the estuarine formation between the Chal and Upper Greensand at Beinn Jadain in Morven, which the autho investigated in the hope of finding plant-remains belonging to tha interesting age. He doubts that the Chalk is *in situ*, and consider the evidence of age to be not quite conclusive.

The second part of the paper deals with the palæontologica evidence. The evidence, if confined to the plants of Ardtun, wa said to be scarcely worth serious discussion, and the analysis wa extended to the far richer plant-bed at Atanekerdluk. The ident fications of these with Miocene plants of Europe were discusse *seriatim*, and shown to be groundless, or only applied to such pr vailing types of leaves as are common to widely distinct genera, an occur in floras recent as well as fossil, and which cannot be supe ficially distinguished in even a living state. The strong resemblanc and even identity of the best-characterized forms with the old Eocene plants has been, on the other hand, hitherto ignored. Th most strongly marked types of Greenland, and which recur i Antrim, are met with in the Heersian of Gelinden and at no oth horizon, and amply suffice to fix the date of the Antrim floras. Th Mull flora, as its aspect indicates, is still older, and consequentl earlier than the Thanet Beds of England. Independently of positiv evidence, the absence of any late Tertiary types, even of the Legu minosæ, which abound as low down as the Reading Beds, sufficientl indicates their extreme antiquity.

2. "On the Echinoidea of the Cretaceous Strata of the Lowe Narbadá Region." By Prof. P. Martin Duncan, M.B., F.R.S., F.G.

A collection of fossils from the Limestone near Bág, in Weste India, made by Colonel Keatinge, was described by the author i the Quarterly Journal of the Society for 1865, and shown to be Upper Greensand or Cenomanian age. The country was subs quently examined, and a sketch-map made by Messrs. Blanford an Wynne, who found near Bág the following beds in descending ord beneath the Deccan and Malwa traps :—Coralline limestone, Argill ceous limestone, Nodular limestone, Sandstone. All were conform able, the whole thickness of limestone did not exceed 50 feet, an the fossils obtained by Colonel Keatinge were shown to have bee exclusively derived from the Argillaceous limestone. All the bed were referred to the same Cretaceous sub-division.

Good topographical maps having been prepared, the area wa remapped by Mr. Bose, who obtained several additional fossils fro the Coralline and Nodular limestones, and a few from the upper bed of the Sandstone. He accepted the Cenomanian age for the Argi laceous limestone, but referred the overlying Coralline limestone to

Senonian age, and the underlying Nodular bed to the Gault, whilst he regarded the Sandstone at the base as probably Neocomian.

Mr. Medlicott, Director of the Geological Survey of India, in compliance with the author's request, had sent to him the Echinoidea collected by all the geologists named, and, on examination, the collection was found to comprise the following eight species:—*Cidaris*, sp. nov., *Salenia Fraasi*, *Cyphosoma cenomanensis*, *Orthopsis*, sp. nov., *Echinobrissus Goybeti*, *Nucleolites similis*, var., *Hemiaster cenomanensis*, and *H. similis*. All the known forms were found in beds of Upper Greensand age in the Lebanon, Europe, etc., except the *Nucleolites*, which was a Chloritic-marl species. Of the eight species all were found in the Argillaceous limestone, five in the Coralline, and two in the Nodular limestone, the last two, *Hemiaster cenomanensis* and *H. similis*, occurring throughout. Under these circumstances there appeared no reason for assigning the beds of limestone to different stages of the Cretaceous system.

3. "On some Dinosaurian Vertebræ from the Cretaceous of India and the Isle of Wight." By R. Lydekker, Esq., B.A., F.G.S.

The author, in 1877, described some Dinosaurian caudal vertebræ and a femur from the Lameta beds of India (Middle or Upper Cretaceous), and as he was unable to find any described forms that resembled them, he proposed for them a new genus, which he called *Titanosaurus*. Two species were represented. After noticing the principal characters of the Indian specimens, he showed that some caudal vertebræ in the British Museum, collected by the late Mr. Fox from the Wealden of Brook, in the Isle of Wight, agreed in form with those found in India, and were, in fact, intermediate in some respects between the two Indian species. An inquiry into the associated remains at Brook indicated that the caudal vertebræ in question probably belonged to *Ornithopsis*, and this probability was supported by the structure of certain American fossil genera placed by Marsh in the same suborder, Sauropoda, of the Dinosauria. In any case there is great probability that at least one of the Indian and the Isle of Wight vertebræ should be referred to the same genus.

Some other instances of fossil vertebrates appearing in Indian beds of a rather later geological age than in Europe were noticed.

4. "Further Notes on the Results of some Deep Borings in Kent." By W. Whitaker, Esq., B.A., F.G.S.

This paper contained some details on the borings at Chattenden Barracks and at the Dover Convict Prison, in addition to those already published in the Quarterly Journal of the Society for 1886. Sections of the new borings, one at Strood, the other at Lydd, were also given.—The Chattenden boring has been successful in reaching the Lower Greensand, and a supply of water had been obtained. This result showed that on the section accompanying the previous paper the beds of the Lower Greensand should have been carried rather further to the northward.—The Dover boring was abandoned at 931 feet from the surface. The examination of the specimens showed that the thickness formerly assigned to the Lower Greensand should be reduced to 31 feet, the upper five feet referred to that stage belonging to the base of the Gault, whilst the bottom, 13 feet,

together with an additional 69 feet, mostly of clay, subsequent cut through, were, for reasons given, assigned to the Wealden seri and probably to the Hastings beds. The results of these addition details went to show (1) that, though the Lower Greensand itself w rather thicker at Chatham than at Dover, comprising two division the Folkestone and the Sandgate beds at the former place, and onl the Sandgate at the latter, the Lower Cretaceous beds, as a whol were much thinner at Chatham, owing to the disappearance of th Wealden series; and (2) that in passing to the eastward the Weal clay thinned out before the Hastings beds, instead of the revers which was previously suggested.—The Strood and Lydd sections wer merely of importance as furnishing details. The paper conclude with some remarks on the best site for additional borings at Dove in order to prove the deeper-lying rocks.

CORRESPONDENCE

THE FFYNON BEUNO CAVE.

Sir,—So much interest has been shown in the Ffynon Beun Cave, and especially in the determination of the age of the bed fro which Dr. Hicks and Mr. Luxmoore obtained the flint implemen that I trust you will allow me space in the Geological Magazin for a few remarks on the mammalian remains which have bee found, and concerning which, as it seems to me, Dr. Hicks is unde a misapprehension. In a note to Dr. Hicks's paper, published in th December Number of this Magazine (p. 567), he alludes to remark made by Prof. Hughes on the same subject (November p. 492), and says: "Prof. Hughes's palæontological argument i found on examination to be almost equally inapplicable, as a very large proportion of the animals occur in the Norfolk Forest Bed which is acknowledged by all to be of Pre-Glacial age. The fac that some others have not been found in the caverns probably indicate that they did not migrate into the area."

The evidence to be derived from the list of mammals given by Dr. Hicks on p. 571 would certainly lead one to the conclusion tha the deposits, from which they were obtained, were of Pleistocen age. It is quite true that most of these species have been found i the Pre-Glacial Forest Bed of Norfolk, and it is probable that other of them will yet be found; although at present the Lion, Reindeer and Woolly Rhinoceros are conspicuously absent from the Forest Bed fauna. On the other hand, the whole of these Ffynon Beun cave mammals are met with in acknowledged Pleistocene deposits. And further, it must be remembered, that the forms which are common to the Ffynon Beuno cave and the Forest Bed are those which link on the Forest Bed to the Pleistocene times; and not those which are characteristic of the Pre-Glacial fauna. This brings us to another, and perhaps the most important point, and that is the entire absence of characteristic Pre-Glacial forms from the Ffynon Beuno cave.

Some of the most characteristic species of the Pre-Glacial Forest Bed are *Rhinoceros Etruscus, Trogontherium Cuvieri, Myogale moschata, Elephas meridionalis,* and several large Deer such as *Cervus Sedgwickii,*

C. verticornis, *C. poligniacus*, *C. Savinii*, etc., and the finding of any one of these forms in the Ffynon Beuno deposit would be strong evidence in favour of its Pre-Glacial age; but not one of them has been found.

With regard to the stratigraphical evidence of the age of this deposit, I have nothing to say: but the mammalian fauna would certainly lead one to assign to it a Pleistocene and not a Pre-Glacial origin. E. T. Newton.

PHOSPHATIC NODULES OF THE SALT RANGE, INDIA.

Sir,—Dr. H. Warth, of the Indian Civil Service, writes from Dehra Dún, under date 17th Nov. 1886, referring to certain nodules of Phosphate of Lime, which he found in overlying shales associated with the Salt Range Coal at the localities of Pid, Dandôt, etc. He speaks of these phosphatic nodules as being "nearly equal in purity" to the "bed" of phosphate of lime at Mussoorie Hill-station, which, so far as I am aware, he was the first to notice in this connexion; having sent me some samples from the locality nearly a year ago.

From this locality, it would seem some inferior specimens had been sent home for examination, by order of Government, the London results giving only one-ninth of the quantity of phosphoric acid found by Dr. Warth's own analysis of better specimens. As to the Salt Range nodules which he has also analyzed, I extract from his letter, viz.:—

"Analysis of phosphatic nodules with hemispherical pores all over the surface from the Pid, Dandôse Colliery, etc., in the Eastern Salt Range; scattered in the shales which overlie the Eocene Coal Seam, and sometimes replacing shells.

	Insoluble silica, etc.	4 per cent.
(P_2O_5)	Phosphorus pentoxide	30 ,,
(CO_2)	Carbon dioxide	4 ,,
(SO_3)	Sulphur trioxide	2 ,,
(Cl)	Chlorine	trace
(Al_2O_3)	Aluminium Oxide	trace
(FeO)	Ferrous Oxide	2 ,,
(MG)	Magnesium Oxide	2 ,,
	Balance, Calcium Oxide, water, organic matter and loss	56 ,,
		100."

The importance of the occurrence of the valuable mineral phosphate of lime in India leads to the hope that Government will take steps to have the Himalayan limestone zones specially explored with regard to such deposits and to their worth. A. B. Wynne.

OBITUARY.

HENRY MICHAEL JENKINS, F.G.S.

Born 30 June, 1841; Died 24 December, 1886.

We have to record with deep regret the loss of a valued friend and sometime colleague in the Editorship of this Magazine (1865), who has passed away at the close of the old year whilst still in the prime of life, with the hope of at least many more years of work before him.

Henry Michael Jenkins was born at Fairwater Mills, Ely, near Llandaff. His father, Mr. John Jenkins, an energetic and clear-

headed corn and flour merchant, died whilst his son was yet an infant, and his mother having been married to Mr. Box, corn merchant, young Jenkins was in due time sent to Mr. Browning's school near Bath. He showed great aptitude for business affairs, first in his step-father's office, then as barter-clerk on a voyage to the west coast of Africa, undertaken for his health (for he early developed symptoms of asthma, from attacks of which he was always liable in unfavourable conditions of the weather), afterwards in the shipowner's office in Bristol. H. M. Jenkins came to London in March, 1859, having been appointed Assistant to Prof. Rupert Jones, in the Geological Society, Somerset House.

Here he won the good opinion of the officers and Council by his intelligence and aptitude for his duties, and on the removal of Prof. T. Rupert Jones, F.R.S., from the Geological Society to the Royal Military College, Sandhurst, Mr. Jenkins was appointed to succeed him in 1862 as Assistant Secretary. He was elected a Fellow of the Geological Society in 1863, and edited the Quarterly Journal with marked success from 1862 to 1868; at the end of the latter year he was chosen Secretary to the Royal Agricultural Society of England, a post which he has held for eighteen years with marked success, not only as Editor of the Society's Journal, but also as Secretary and Manager of its Annual Shows.

Mr. Jenkins's career, extending over twenty-seven years, has been one of steady upward progress, due to his indomitable energy and great capacity for mastering rapidly the details of all matters, whether scientific or commercial, which it was needful for him to understand and decide about judicially. His business shrewdness enabled him to save the Royal Agricultural Society hundreds of pounds annually, and his scientific ability as Editor has brought their Journal up to a standard of excellence which few Societies can equal and probably none surpass.

Mr. Jenkins was, in the early days of his career, for some time assistant editor to Mr. Samuelson, in conducting the Quarterly Journal of Science, to the pages of which he contributed many Reviews and Notices, also to the GEOLOGICAL MAGAZINE and the Quarterly Journal. We give the titles as under :—

"On the Tertiary Mollusca from Mount Séla, in the Island of Java." Quart. Journ. Geol. Soc. 1864, vol. xx. pp. 45–73, pl. vi.–vii.

"On the Occurrence of a Recent Species of *Trigonia* in Tertiary Deposits in Australia." GEOL. MAG. 1866, Vol. III. p. 201, Pl. X.

"Hypothetical Continents." Intellectual Observer, 1866, vol. x. pp. 88–97.

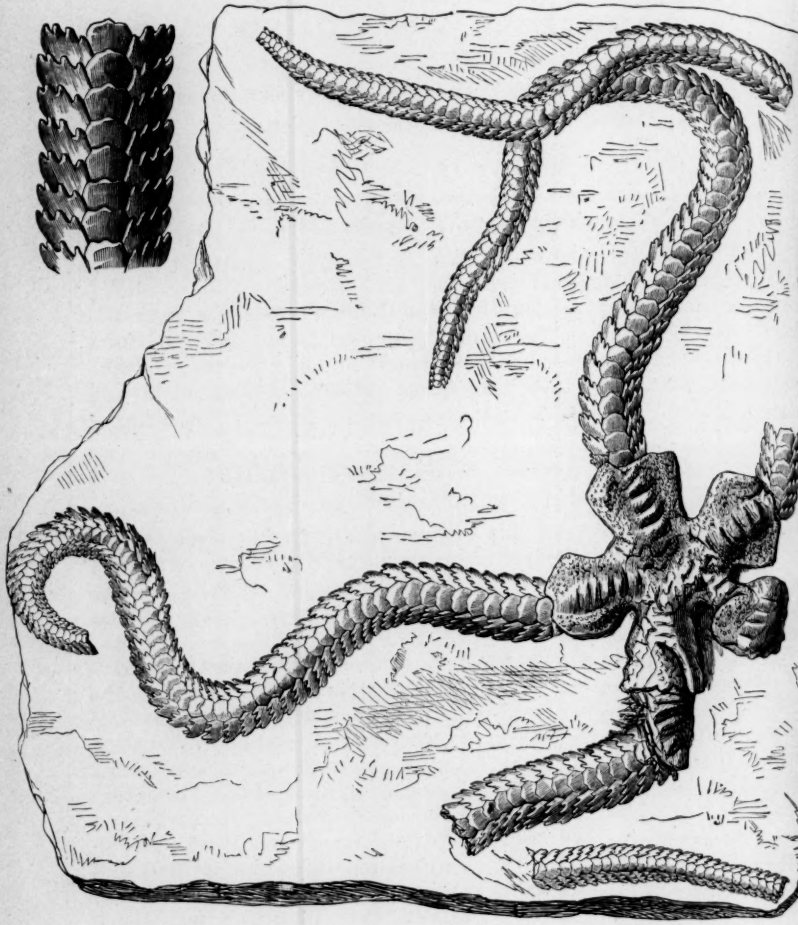
"Brackish Water Fossils in Crete." Quart. Journ. Science, 1864, vol. i. pp. 413–421 (Plate No. 3).

"Strata Identified by Organic Remains." Quart. Journ. Sci. 1865, vol. ii. pp. 622–630 (Plate No. 8).

"Amber; its Origin and History." Quart. Journ. Sci. 1868, vol. v. pp. 167–18 (with a Map and Plate).

"On *Palæocoryne*" (Joint paper with Prof. Duncan, F.R.S.), Phil. Trans. Roy. Soc. 1869.

The numerous writings of his later years have been directed to Agriculture in all its branches, and in the future his name will be best remembered by these; but his memory will be cherished by all who knew him, whether Geologists or Agriculturists.



Ophiurella nereidea, Wright.

Calcareous Grit, near Weymouth.